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Dance, embodied agency and neuroplasticity in aging

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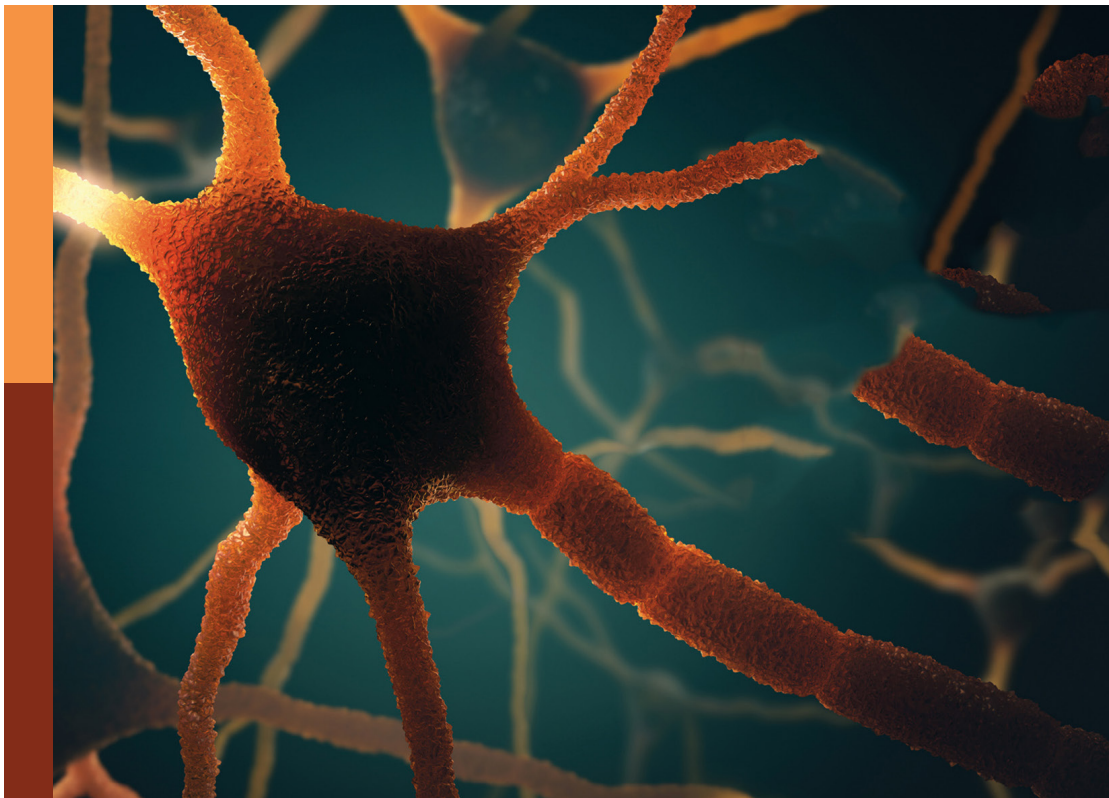

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Dance, embodied agency and neuroplasticity in aging

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Editorial: Dance, embodied agency and neuroplasticity in aging

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Editorial on the Research Topic
Dance, embodied agency and neuroplasticity in aging

Dance is a multi-modal artistic engagement whose group-delivered protocols have resulted in positive impacts on elderly health (Roberts et al., 2017; Liu et al., 2021). Since the 2022 Research Topic on dance and the elderly was published (Markula et al., 2022), reports from arts-science research collaborations have shown numerous ways person- and community-centered arts-based approaches have extended health across quality-of-life domains among aging adults (Fancourt and Steptoe, 2019; Golden et al., 2023). For dance, such improvements have been reported from training in many different dance styles—structured (modern dance), improvisational, culturally stylized and technologically-assisted. The research is promising, particularly as many barriers to dancing have been removed and ease of access has improved for diverse populations. Nonetheless, important research gaps remain, specifically in articulating the social benefits of dance and their impact on agency (Kaczmarska, 2023; Jensen et al., 2024; Kontos and Grigorovich, 2018). As an aesthetic art form, dance participation couples brain-body health with a range of communicative abilities bearing on relationality and meaning (Warburton, 2011). Data on psychosocial skills of attention, listening, cooperation, self-regulation and empathy are not commonly collected or reported in quantitative research. Valuing such nontangible factors is particularly relevant first in promoting independence and in decreasing the perceived and actual burden of aging on general health and wellbeing. Further, critical to research advancement is the need to distinguish and differentiate functional and neuroplastic outcomes comparing dance protocols with comparable dosages of repetitive fitness exercise (Rehfeld et al., 2018; Müller et al., 2017). Last, the impact of aesthetic factors on health remains understudied (Chappell et al., 2021; Fontanesi and DeSouza, 2021).

For this special Research Topic on dance and health in older adults, our interest focused around the interaction of qualitative and quantitative factors. Specifically, we solicited studies that address how dance participation could foster embodied agency, as well as induce positive neuroplastic changes in the brains of elder adults across different populations.

Manuscripts submitted reflected a global scope of collaborative research between dance educators and neurological and behavioral scientists, including Brazil, Canada, Italy, the United Kingdom, and the United States). Included in this Research Topic are original clinical research, case series, conceptual analysis, and perspectives articles, in which researchers critically analyze interrelated connections and interactions of physical psychological, aesthetic, cultural and social meanings of dance for older persons. Although the Research Topic offers a small sampling of the scope of the topic of embodied agency through dance (nine articles, plus Editorial), they represent an evocative variety of mixed methodologies in both quantitative science and qualitative phenomenological, sociological and cultural research.

The Research Topic opens with a perspective by Sheets-Johnstone, dance philosopher, who emphasizes the need to explicate the neurological and kinesthetic coordination dynamics embodied within dance, dynamics which are critical to engendering health of the whole body.

In a conceptual analysis of an Italian study on dance and Parkinson's disease, Houston extrapolates "soft skills"—"anoetic knowledge," data which, when expressed through dance, preface a sensate, emotional and affective state of mind—one critical to self- and other-care, vulnerability, patience, and other indicators of meaningful social engagement.

Other samples from the Research Topic include original clinical research: a randomized controlled study on social determinants of health by Worthen-Chaudhuri et al., reporting improvements in autonomy, competence and relatedness for persons with chemotherapy-induced neuropathy. In three studies, researchers designed digitally assisted technology in their dance/movement protocols: First, Delabary et al. reported sustained improvements from Brazilian dance for older adults living with Parkinson's disease, despite switching from on-site to online learning during the COVID 19 epidemic. Second, emplying a protocol or virtual ballet and wellness classes, Harrison et al. reported combined qualitative and quantitaqtive improvements in measures of social efficacy and gait and balance for a group of elderly women. Third, the use of group-delivery of visual assisted feedback of hand gestures by Hansen et al. proved aesthetically "irresistible," in stimulating movement learning.

The article by Barnstaple et al., speaks to the need for transdisciplinary researchers to rise to the challenge of capturing nuance in "full bodied reporting." They pose methodological questions and offer guidelines that point the way toward improving sensitivity, reliability and replicability in research designs.

We invite readers to explore all the articles in this Research Topic and thank *Frontiers* for affording us the opportunity to pursue this project. We trust that in reading the articles in this Research Topic, readers will broaden their understanding of ways that dance offers a lived experience of embodiment, relationality, and meaning, integral to building a paradigm of mind and body holism and unity. As scientists consider the value of dance on health and wellbeing in aging, the collective contributions of the artists, participants, and clinicians will assist in building authentic and mutually beneficial relationships among the medical and public communities served.

Author contributions

GB: Conceptualization, Supervision, Writing – original draft, Writing – review & editing. BB: Writing – original draft, Writing – review & editing. JD: Writing – original draft, Writing – review & editing. AN: Writing – original draft, Writing – review & editing. CH: Writing – original draft, Writing – review & editing.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Graceful gait: virtual ballet classes improve mobility and reduce falls more than wellness classes for older women

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Introduction: Dance is an effective and motivating form of exercise for older women, but few studies have quantified the benefits of virtual dance classes nor, specifically, ballet. This study tested the effectiveness of virtual ballet compared to virtual wellness classes, with the goal of reaching underserved populations. It is among the first to explore the effects of virtual classical ballet on functional gait mobility, balance, and quality of life measures in older women.

Methods: Older women were recruited in two waves and randomized to two groups: a ballet class modified for older adults and a wellness-based control class. Both groups received 12 weeks of online classes, meeting twice per week for 45-min sessions. Classes were taught by a local company that offers community-based ballet classes. The same instructor led both the ballet and the wellness classes. Pre- and post-intervention assessments include gait and balance testing using wearable inertial sensors and self-report outcomes including quality of life and mood questionnaires.

Results: Forty-four older women completed the study: Ballet group ($n = 21$, 67.81 ± 7.3 years); Wellness group ($n = 23$, 69.96 ± 6.7 years). Pre- to post-intervention, both groups increased velocity on the two-minute walk test ($F_{1,42} = 25.36$, $p < 0.001$) and improved their time on the Timed Up and Go ($F_{1,42} = 4.744$, $p = 0.035$). Both groups improved balance on the Mini-BESTest ($F_{1,42} = 38.154$, $p < 0.001$), increased their scores on the Activities-Specific Balance Confidence Scale ($F_{1,42} = 10.688$, $p < 0.001$), and increased quality of life via the Short Form Health Survey ($F_{1,42} = 7.663$, $p = 0.008$). The ballet group improved gait variability in the backward direction ($F_{1,42} = 14.577$, $p < 0.001$) and reduced fall rates more than the wellness group [$\chi^2(1) = 5.096$, $p = 0.024$].

Discussion: Both virtual ballet and wellness classes improve select measures of gait, balance, and quality of life. The benefits seen in both groups highlight the importance of considering social interaction as a key component when developing future interventions to target mobility in older women.

KEYWORDS

dance, mobility, kinesthetic empathy, dual task, socialization, ballet

1 Introduction

Falls are a major cause of disability in older adults. Every second of every day an older adult, aged 65 or older, suffers a fall in the US, leading to 30 million falls each year (CDC, 2019). Women, who are more likely than men to experience bone density loss in older age, are particularly susceptible to falls and account for 75% of all hip fractures regardless of gender (Gale et al., 2016). Even a single fall can be debilitating, leading to a fear of falling, withdrawal from activities, and reduced quality of life (Bower et al., 2016).

The two primary factors that contribute to fall risk among older adults are decline in gait and decline in balance ability (Kyrdalen et al., 2019). Gait impairment affects one third of the population over 70 years of age and represents a major cause of falls (Verghese, 2006). Gait speed, in particular, is a robust marker of overall health, as reductions in self-selected gait speed with aging can predict adverse events, future disability, healthcare utilization, and even mortality (Cesari et al., 2005). Slower walking can also lead to more variability between steps, rendering walking less stable (Kang and Dingwell, 2008). Increased gait variability in older adults is correlated to higher fall risk (Hausdorff et al., 2001). Multifactorial interventions for older adults that increase gait speed and decrease gait variability may help reduce fall rates (Gillespie et al., 2021).

Balance is a complex activity that requires coordinating multiple body systems. Effective balance involves maintaining upright posture during static conditions as well as facilitating movement during dynamic tasks, such as walking (Horak, 2006). Balance decline in aging involves reduced strength, flexibility, and sensory loss, which collectively contribute to fall risk (Kanekar and Aruin, 2014). Older adults at risk of falling, when compared to those who are not, are unable to hold static postures as long (Araujo et al., 2022), exhibit increased postural sway during standing balance tasks (Oliveira et al., 2018), and perform worse on dual cognitive-motor tasks (Verghese et al., 2002).

Dance is a multi-modal artform that provides an effective therapy for addressing gait and balance impairments in older adults as it combines multi-sensory elements including proprioceptive, visual, auditory, and motor control techniques (Earhart, 2009). In-person dance interventions for older adults frequently show benefits to functional mobility (Hwang and Braun, 2015; Britten et al., 2017). Gait improvements have been reported across a broad range of dance styles showing improvements in stride velocity (Granacher et al., 2012), walking endurance (Shigematsu et al., 2002; Hui et al., 2009), and muscle function (Cepeda et al., 2015). Balance improvements are reported in a similarly wide variety of dance styles including contemporary (Ferrufino et al., 2011; Coubard et al., 2014), jazz (Wallmann et al., 2009), ballroom (Cepeda et al., 2015), salsa (Granacher et al., 2012), tango (Hackney et al., 2007; Hackney and Earhart, 2009; Earhart, 2013; Sofianidis et al., 2017), and traditional folk dance (Eyigor et al., 2009; Sofianidis et al., 2009; Pacheco et al., 2016). Furthermore, cross-sectional studies show that older adults who dance regularly have better balance capabilities than those who do not (Verghese, 2006; Dewhurst et al., 2015).

Classical ballet interventions for older adults, however, remain underrepresented in the literature despite ample evidence to suggest that they might be useful in older populations (Hwang and Braun, 2015; Weighart and DiPasquale, 2020). Ballet trains postural stability through a mix of static and dynamic processes that may translate to gait and balance improvements. The use of a ballet barre renders training feasible and safe for older adults, while encouraging stability and upright posture during standing exercises. Ballet is highly adaptable to home studio settings, as stationary chairs readily substitute for ballet barres and much of the class period can be done in a small room with minimal shifting of the camera. Ballet classes emphasize sensorimotor integration (Tanabe et al., 2014) and teach specific visual and proprioceptive techniques that may aid postural control and body awareness (de Mello et al., 2017). Ballet combinations are cognitively challenging and require complex coordination of multiple body parts. Emphasis on movement sequencing, timing, and efficiency may help with dynamic movement tasks (Kiefer et al., 2011). Ballet may also teach strategies for complex movement tasks, such as backward or dual task walking, that frequently lead to falls (Muir-Hunter and Wittwer, 2016; Bayot et al., 2020). Focusing on full-body stabilization during ballet may challenge the body to constantly recalibrate and adjust to destabilizing forces (Weighart and DiPasquale, 2020).

Dance interventions not only address mobility issues, but also promote cognition, emotional expression, kinesthetic awareness, and social engagement (Hwang and Braun, 2015; Clifford et al., 2023). During the COVID-19 pandemic, many dance therapy classes moved online, which afforded the convenience and safety of participating from one's own home but removed elements of social interaction and group support that are naturally structured into in-person classes (Bek et al., 2022). Kinesthetic empathy, or the ability to perceive others' emotions through action observation, is a key component of in-person classes (Christopher and Tamplin, 2022) that may occur less spontaneously during virtual classes. While in-person classes have resumed, online classes often remain available for people who are unable to travel or need flexibility to participate from home; however, little is known about how much benefit online classes provide.

Though the main objective of the interventions was to improve functional mobility, we also assessed the synergistic interactions of mind and body reflected through complex motor dual-tasks, quality of life, and mood. In order to test the effects of ballet on gait and balance, he primary outcome measures were gait velocity and postural stability. Secondary measures were balance confidence, fall frequency, quality of life, and mood measures. We hypothesized that the ballet intervention would be more effective at improving gait and balance measures than the wellness intervention, but that both interventions would equally improve quality of life and mood.

2 Methods

The interventions consisted of a ballet class that utilized a pre-existing model of classical ballet modified for older adults, and a wellness class that served as a control intervention. The original intent of the study was to research in-person ballet classes, but due to COVID-19, the study moved entirely online well before the start of the study. The study was approved by the Washington University IRB and all participants gave written informed consent.

2.1 Participants

Older women aged 55 and above were recruited from local community centers, senior residences, and senior assistance

organizations. Participants were recruited via flyers in two waves. Covariate adaptive randomization (Kang et al., 2008) counterbalancing for age was used to divide participants into two groups: a ballet class and a wellness class.

Recruitment was limited to women as they are at higher risk of frailty, hip fractures from falls, and physical inactivity than men (CDC, 2019). Additionally, women report higher anxiety and more depressive symptoms than men (Nair et al., 2021) and may therefore benefit more from interventions targeted at improving quality of life and mood.

In addition to the inclusion criteria of age and gender identity, participants needed to be able to walk independently with or without an assistive device for at least 5 min. Exclusion criteria were ballet training in the last 2 years; evidence of dementia (Mini-Mental Status Examination <24); language, visual, or hearing barriers to participation; and/or history of orthopedic or other medical problems that limit ability to participate safely in the intervention. To be included in the final analysis, participants needed to attend 70% (minimum 17 of 24) of the classes.

Sixty-five participants were recruited but 21 dropped out or had poor attendance due to extenuating factors during the pandemic including health reasons, caretaking responsibilities, and technology issues. Several people randomized to the wellness class dropped out before the classes started because they were displeased with their class placement. Attendance was taken daily; participants missed classes due to a range of conflicts such as work obligations, caretaking responsibilities, technology issues with Zoom, and vacations. Forty-four participants completed the intervention with enough classes to be included in the final analyses: ballet group ($n = 21$); wellness group ($n = 23$) (Table 1). The groups were well-matched in terms of baseline dance experience and mobility measured via gait speed. We made concerted effort to include participants from under-represented groups.; 20.45% (9/44) of the participants were non-white.

TABLE 1 Participant demographics.

		Ballet	Wellness	*p*
N		21	23	
Age		67.81 (7.3)	69.96 (6.7)	*0.33*
Race (*n*)	White	16	19	
	Black	4	3	
	Asian	1	1	
Comorbidities (*n*)	0	5	3	
	1	6	10	
	2	7	7	
	>2	3	3	
Retirement status		57%	83%	
Education level	Some college or trade school	5%	22%	
	College degree (Associates)	5%	17%	
	College degree (Bachelors)	47%	13%	
	Post college	43%	48%	
Living situation	Alone	28%	22%	
	With partner	48%	61%	
	With family (in addition to partner)	0%	4%	
	With family (other than partner)	24%	13%	
Dance experience (years)		3.26 (7.1)	3.05 (3.4)	*0.14*
Baseline velocity (m/s)		1.40 (0.28)	1.49 (0.25)	*0.29*
Baseline Mini-BESTest, median (range)		24 (13,32)	24 (10,31)	*0.1*

Values are mean ± SD unless noted. *T*-tests were used for between-group comparisons. Baseline velocity is taken from 2MWT. Baseline Mini-BESTest score refers to overall score.

2.2 Class structure

All classes were taught by a local organization, *Vitality in Motion* https://vitalityinmotion.com/, that offers high-quality, community-based ballet classes. Both groups received 12 weeks of online classes, in accordance with dosage recommendations for dance interventions (Hackney et al., 2007; Hackney and Earhart, 2009, 2010; Hwang and Braun, 2015). Both groups met two mornings per week over Zoom (Zoom Video Communications Inc., San Jose CA) for 45-min sessions, as is the standard length of *Vitality in Motion* classes.

The ballet classes followed conventional class formats utilizing ballet movement vocabulary and were set to classical music (Table 2). Classes were tailored to older populations and modified according to individual or group needs. Each class began with seated warm-up exercises that progressed to standing "barre work" using chairs for support. Some "center work" done in the middle of the room without the barre allowed participants to practice movement sequencing, memorization of steps, and expressive choreography while freely moving in space.

Modifications for virtual settings were intended to closely replicate the in-person class experience. Students were able to see and mimic the teacher's movements throughout the class. There were no mirrors, but participants used their own cameras to provide visual feedback of their own performance. The online format via Zoom allowed for constant monitoring of bodies synchronizing in space, allowing for embodied interaction with others in real-time. A member of the research team was present to monitor each session and help participants with technology needs and ensure safety. To account for social interactions that typically occur during group classes, the monitor opened up the Zoom class 10 min early for participants to unmute and chat. We had no issues with Zoom during the classes. Some issues for individual participants did arise (i.e., not being able to connect to wifi, not being able to hear, not being able to find adequate space) and resulted in participants not being included in analyses.

The control intervention was selected as an active intervention that held steady variables such as class size, duration, socialization, and instructor demeanor but did not involve movement. We thought this a better comparison than utilizing a control condition that involved no intervention, which is often the default in early phase studies of movement interventions. The wellness classes (Table 2) were led by the same instructor as the ballet classes to control for any effect of the instructor's demeanor or personality. In these education-based classes, participants discussed topics related to wellness and aging. No

TABLE 2 Structure of ballet and wellness classes.

Ballet class	Wellness class
I Greetings and announcements	I Greetings and announcements
II Opening warm-up	II Opening presentation on a health topic
i *Stretching*	Example topics:
ii *Mobility exercises*	i *Isolation during Covid*
III Ballet barre behind chair:	ii *Nutrition*
i *Pliés*	iii *Hydration*
ii *Tendus*	iv *Physical activity*
iii *Dégagés*	v *Mindfulness*
iv *Ronde de jambes*	vi *Sleeping*
v *Piqués*	vii *Brain health*
vi *Petite battements*	viii *Mental health*
vii *Adagio: développés/enveloppés/fondus*	ix *Fall prevention*
viii *Balancés*	III Discussion of topic among participants
IV Ballet walking exercises in center	i *Participants given equal time to speak*
V Reverence	IV Closing remarks

movements or exercises were performed during any of the wellness classes. Educational presentations were given each class by the instructor and followed with time for the participants to discuss their own experiences. This control comparator intervention was selected based on recommendations by an NIH expert panel on health-related behavioral interventions (Freedland et al., 2019).

2.3 Assessments

All participants underwent a comprehensive evaluation at two time points: pre-intervention and post-intervention. Evaluations occurred within 2 weeks of the start/end of classes. The same battery of assessments was used at both time points. Assessors were blinded to group assignment. As falls are multifactorial, commonly used assessments of gait and balance do not adequately predict fall risk in older adults in isolation (Omaña et al., 2021); therefore, multiple measures were assessed in this study.

The assessments consisted of motor and self-reported outcomes. During the motor exam, gait was captured during free walking using six wearable sensors (feet, wrists, sternum, lumbar) (APDM Mobility Lab, APDM Inc., Portland, OR). Sensors provided detailed information regarding spatiotemporal features of gait during the 2-min walk test (2MWT) and the 10-m walk test (10MWT). The 10MWT was assessed in four conditions, each performed three times: comfortable pace, fast as possible pace, dual-task (while doing a verbal cognitive task), and backward walking. Variables of interest included: stride velocity, stride length, and stride time as well as the coefficient of variation (CV) of stride velocity, stride length, and stride time.

Balance was assessed via the Mini Balance Evaluation Systems Test (Mini-BESTest), a well-validated tool that measures both static and dynamic balance, functional mobility, and gait (Marques et al., 2016). Postural sway during static balance tasks was measured via wearable sensors during single leg stance (SLS) performed twice on each leg in 30-s bouts. Balance variables were selected based on high validity and reliability and calculated within APDM software. These included duration, total sway area (computed as the area included in the acceleration per unit of time), jerk (smoothness of sway from time derivative of acceleration), mean velocity, and mean RMS (root mean square of the ACC time series). Greater static balance control is associated with higher duration (Baker et al., 2021) and lower sway area (Sohn et al., 2023), jerk (Mancini et al., 2012), mean velocity (Borysiuk et al., 2018), and mean RMS (Alsubaie, 2020). Additionally, self-reported balance confidence was measured via the Activities-Specific Balance Confidence Scale (ABC) (Schepens et al., 2010).

Sensors captured three trials of both the simple Timed Up-and-Go (TUG) and dual-task cognitive TUG (DT-TUG) in which participants subtracted backwards from 100 by threes. Dual task cost was calculated according to the following formulaw:

$$\left(DT\ cost = \frac{DT\ TUG\ duration - TUG\ duration}{(TUG\ duration)} \times 100 \right)$$

(Piche et al., 2023).

Questionnaires assessed quality of life [Short Form Health Survey (SF-36)] and mood [Geriatric Depression Scale (GDS)]. Self-reported fall frequency was reported at both time points and summated for the 3 months prior. Participant demographic information was also collected. Most common comorbidities reported were arthritis, high cholesterol, and hypertension.

Statistical analyses were conducted using IBM SPSS 27. We employed two-way repeated measures (RM) ANOVAs with group (ballet vs. wellness) and time (pre- vs. post-intervention) as factors to determine how the interventions impacted outcome variables. Fall rates were compared via logistic regression and the likelihood ratio was calculated via a Chi-square test. Post-hoc pairwise comparisons were used as appropriate, and Bonferroni corrections were used to correct for multiple comparisons. Statistical significance was set at $p = 0.05$.

3 Results

3.1 Gait results

In the 2MWT, there were main effects of time for velocity and stride length, which increased from pretest to posttest for both groups (Table 3). There was also a main effect for stride time which decreased for both groups.

Among the 10MWT conditions, we observed one group x time interaction, which was for stride time in the 10MWT at a comfortable pace. Pairwise comparisons revealed that ballet participants reduced stride time ($p = 0.029$) whereas wellness participants increased it ($p = 0.008$). Additionally, for the main effect of time, stride length in the backward direction increased regardless of group.

3.2 Gait variability results

For gait variability in the 2MWT, there was a main effect of time showing an increase (i.e., worsening) in gait velocity variability (Table 4). An interaction effect showed that this was driven by the ballet group.

However, in the 10MWT, the ballet group showed the most improvement in the DT and backwards conditions. In the DT condition, there were group x time interactions for velocity CV and

TABLE 3 Gait characteristics.

		Ballet		Wellness				
		Pre	Post	Pre	Post	Main effect of time	Main effect of group	Interaction effect
2 MWT	Velocity (m/s)	1.40 (0.27)	1.47 (0.29)	1.49 (0.26)	1.54 (0.27)	**<0.001***	0.336	0.520
	Stride length (m)	1.35 (0.18)	1.36 (0.18)	1.36 (0.16)	1.38 (0.16)	**0.002***	0.768	0.578
	Stride time (s)	0.97 (0.08)	0.94 (0.08)	0.92 (0.07)	0.91 (0.02)	**<0.001***	0.070	0.131
10 MWT comfortable	Velocity (m/s)	1.17 (0.23)	1.18 (0.20)	1.22 (0.16)	1.22 (0.21)	0.628	0.447	0.434
	Stride Length (m)	1.22 (0.17)	1.23 (0.16)	1.24 (0.12)	1.24 (0.14)	0.542	0.765	0.961
	Stride Time (s)	1.07 (0.08)	1.05 (0.06)	1.02 (0.07)	1.03 (0.07)	0.652	0.121	**0.041***
10 MWT dual task	Velocity (m/s)	1.02 (0.23)	1.04 (0.23)	1.10 (0.17)	1.08 (0.21)	0.767	0.323	0.251
	Stride Length (m)	1.12 (0.18)	1.14 (0.17)	1.16 (0.13)	1.16 (0.14)	0.475	0.599	0.370
	Stride Time (s)	1.13 (0.11)	1.12 (0.10)	1.06 (0.08)	1.09 (0.11)	0.715	0.105	0.112
10 MWT fast as possible	Velocity (m/s)	1.53 (0.27)	1.56 (0.27)	1.64 (0.22)	1.64 (0.21)	0.229	0.177	0.264
	Stride length (m)	1.38 (0.16)	1.38 (0.16)	1.40 (0.15)	1.42 (0.15)	0.114	0.498	0.456
	Stride Time (s)	0.91 (0.07)	0.90 (0.08)	0.86 (0.06)	0.87 (0.06)	0.699	0.058	0.108
10 MWT backward	Velocity (m/s)	0.80 (0.26)	0.83 (0.26)	0.86 (0.22)	0.88 (0.26)	0.139	0.475	0.497
	Stride Length (m)	0.82 (0.21)	0.86 (0.21)	0.86 (0.18)	0.87 (0.19)	**0.017***	0.609	0.128
	Stride Time (s)	1.07 (0.15)	1.06 (0.12)	1.03 (0.10)	1.03 (0.14)	0.814	0.346	0.613

Values are mean ± SD. * Indicates significant main effect, $p < 0.05$. 2MWT, two minute walk test. 10MWT, ten meter walk test. Asterisks and bold font indicate significance.

stride length CV revealing that ballet participants improved whereas wellness participants worsened. In the backward direction, main effects of time showed that both groups improved variability measures, including velocity CV, stride length CV, and stride time CV. There were no main effects of group, but a significant group x time interaction for velocity CV indicated that this improvement was driven by the ballet group.

3.3 Balance results

There was a main effect of time for scores on the Mini-BESTest ($F_{1,42} = 38.15$, $p < 0.001$) (Figure 1) and balance confidence as measured by the ABC ($F_{1,42} = 10.69$, $p = 0.002$). The ballet group increased Mini-BEST scores from a mean (range) of 24 (13,32) to 28 (18,32) and the wellness group increased 24 (10,31) to 28 (20,32). For balance confidence measured via the ABC, there was a main effect of time The group × time interaction trended toward significance ($F_{2,41} = 3.86$, $p = 0.056$) as the ballet group increased ABC scores from 86.57 (2.4) to 92.64 (1.57) while the wellness group increased from 89.99 (2.31) to 91.50 (1.50).

Static balance also exhibited a main effect of time as measured by postural sway during single leg stance. From pretest to posttest, the duration that participants were able to hold a static standing posture in single leg stance ($F_{1,42} = 12.69$, $p < 0.001$) increased [Ballet: 12.48 s (8.45) to 15.85 s (8.53), Wellness: 14.20s (8.49) to 16.22 s (9.19)]. In single leg stance, RMS Acc ($F_{1,42} = 5.11$, $p = 0.029$) decreased over time, indicating more stability. There were no main effects of group.

There was no change in the TUG duration ($p = 0.066$), but there was a main effect of time for the DT-TUG duration ($F_{1,42} = 4.279$, $p = 0.045$), with the ballet group duration reducing from 14.23 s (±4.56) to 13.90s (±3.87) and the wellness group reducing from 13.33 s (±2.37) to 12.30s (±2.07). Dual task cost decreased from pretest to posttest ($F_{1,42} = 4.744$, $p = 0.035$) with no effect of group.

3.4 Fall rates

There was a significant effect of group on fall rates [$\chi^2(1) = 5.096$, $p = 0.024$], as ballet participants reduced fall rates from pretest to posttest (19 to 0%) whereas wellness participants increased fall rates (9–13%). When removing the covariate adjustment for participants' baseline fall rates, a significant difference in posttest falls remains [$\chi^2(1) = 4.092$, $p = 0.043$].

3.5 Quality of life, mood, and class satisfaction

Both classes were associated with improvements in quality of life as measured by the SF-36 ($F_{1,42} = 7.66$, $p = 0.008$). Mood, as measured by the GDS, did not change significantly in either group ($F_{1,42} = 3.45$, $p = 0.07$) [Ballet: 5.29 (±0.21) to 4.95 (±0.19); Wellness: 5.17 (±0.20) to 4.96 (±0.182)].

The ballet group responded more positively in the post-intervention survey, with 71% of participants wishing to continue the classes compared to 47% of the wellness participants. Ballet participants reported that the classes improved strength, balance, and flexibility, that they were beneficial for daily activities, and that the classes made them "feel different," "want to move again," and inspired a "positive vibe." Wellness participants gave feedback that they thought the classes were effective, enjoyable, and educational. Many noted a benefit of connecting with other women during a time of isolation due

TABLE 4 Gait variabilities.

		Ballet		Wellness				
		Pre	Post	Pre	Post	Main effect of time	Main effect of group	Interaction effect
2 MWT	Velocity CV	3.84 (1.09)	5.03 (2.3)	4.45 (1.95)	4.51 (1.53)	**0.015***	0.913	**0.028***
	Stride length CV	2.82 (0.88)	3.17 (1.40)	3.10 (1.39)	3.21 (1.19)	0.069	0.654	0.356
	Stride time CV	1.98 (0.71)	2.65 (1.9)	2.38 (1.06)	2.38 (0.92)	0.094	0.851	0.099
10 MWT comfortable	Velocity CV	4.13 (1.42)	3.62 (1.36)	3.69 (2.01)	3.50 (1.09)	0.101	0.488	0.444
	Stride length CV	3.20 (1.00)	2.94 (1.26)	2.66 (1.33)	2.68 (0.70)	0.396	0.183	0.328
	Stride time CV	1.96 (0.69)	1.82 (0.55)	1.20 (1.12)	1.86 (0.57)	0.266	0.914	0.910
10 MWT dual task	Velocity CV	5.22 (2.56)	4.42 (1.62)	4.03 (1.27)	4.62 (1.76)	0.685	0.320	**0.013***
	Stride length CV	4.17 (1.88)	3.48 (1.28)	3.14 (0.98)	3.64 (1.47)	0.667	0.254	**0.011***
	Stride time CV	2.65 (1.31)	2.43 (0.89)	2.17 (0.65)	2.37 (0.89)	0.918	0.298	0.109
10 MWT fast as possible	Velocity CV	3.93 (1.21)	4.18 (1.21)	3.44 (1.06)	4.00 (1.69)	0.070	0.322	0.481
	Stride length CV	3.30 (1.13)	3.58 (1.48)	2.87 (1.06)	2.87 (0.87)	0.482	0.056	0.476
	Stride time CV	2.05 (0.64)	2.23 (0.80)	2.17 (0.74)	2.09 (0.40)	0.676	0.953	0.235
10 MWT backward	Velocity CV	17.68 (1.09)	13.50 (1.23)	13.58 (1.04)	13.52 (1.18)	**<0.001***	0.185	**0.001***
	Stride length CV	13.92 (0.81)	11.14 (1.05)	11.05 (0.78)	10.72 (1.0)	**0.016***	0.157	0.054
	Stride time CV	6.13 (0.46)	5.26 (0.46)	6.34 (0.44)	6.07 (0.44)	**0.025***	0.394	0.229

Values are mean ± SD. * Indicates significant main effect, $p < 0.05$. 2MWT, two minute walk test. 10MWT, ten meter walk test. CV, coefficient of variation. Asterisks and bold font indicate significance.

to COVID-19. Others noted that they became more grateful for their situations and learned to appreciate their health and communities.

4 Discussion

This study is among the first to explore the potential of virtual dance classes to benefit multiple domains of health. Our results show that both virtual ballet and wellness classes improved gait velocity, postural sway, and quality of life for older women. The ballet participants, however, improved more on complex, challenging tasks, such as dual-task walking and backward walking. Ballet classes seemed to be engaging and enjoyable, allowing people to creatively and artistically express agency and to connect kinesthetically with other women during a time of isolation. Wellness classes provided an outlet for informed knowledge-sharing while bonding with women at similar stages of life experience. The parallel improvements in quality of life and mobility highlight the importance of considering social engagement during both virtual and in-person movement therapies.

Ballet participants exhibited two notable improvements in gait variability, a known marker of fall risk, both in the most complex and attention-demanding walking paradigms: dual-task walking and backward walking. Dance is known to improve dual tasking, particularly in people with basal ganglia disorders like Parkinson disease (Kalyani et al., 2019). Ballet requires constant task-switching as people aim to remember combinations, integrate visual and auditory cues, perform complex movement patterns, and fulfill aesthetic goals. Significant reductions in variability in dual task and backward walking may reflect the potential of dance—and ballet, specifically—to train attention and focus during complex motor tasks, freeing up cognitive reserves for more successfully fulfilling the motor task. Such benefits may hold therapeutic meaning as challenging gait tasks require more cognitive reserve and frequently pose the greatest risk of falls (Verghese et al., 2002; Springer et al., 2006; Bayot et al., 2020). This explanation would support a recent study of young adult ballet dancers showing that ballet skills transfer to complex walking tasks such as walking across a narrow beam (Sawers and Ting, 2015).

In another complex motor task, the DT-TUG, which has been shown to discriminate fallers from non-fallers (Schoene et al., 2013), our participants' (regardless of group) mean duration at baseline (13.78 s) surpasses a previously validated threshold of 13.5 s and suggests that many were within the range of fall risk (Steffen et al., 2002). The mean reduction to 13.06 s at posttest suggests that, overall, participants reduced indicators of fall risk. The improvement for both groups in dual task cost suggests that the interventions may have improved cognitive flexibility and adaptability during complex motor tasks, which could help people maintain postural control during tasks that divide attention and elicit falls (Verghese et al., 2002).

In terms of balance, improvements in the Mini-BESTest and ABC suggest global improvements in both objective and subjective stability. We expected ballet participants to improve both balance and balance confidence, confirming our hypotheses. However, wellness participants also improved in multiple domains of balance as well, which was unexpected. As the Mini-BESTest is negatively associated with fall prediction, the mean improvements for the ballet group of 2.4 and the wellness group of 3.1 are meaningful. A 1-point reduction in this test can increase the odds of a fall in the next 6 months by 14% for adults over the age of 60 and this percentage increases each decade (Magnani et al., 2020). Hence, our participants who improved their scores may have significantly reduced their risk of falls.

Static balance improved in only a few measures. Improvement in SLS duration and RMS acceleration are important as they correlate to

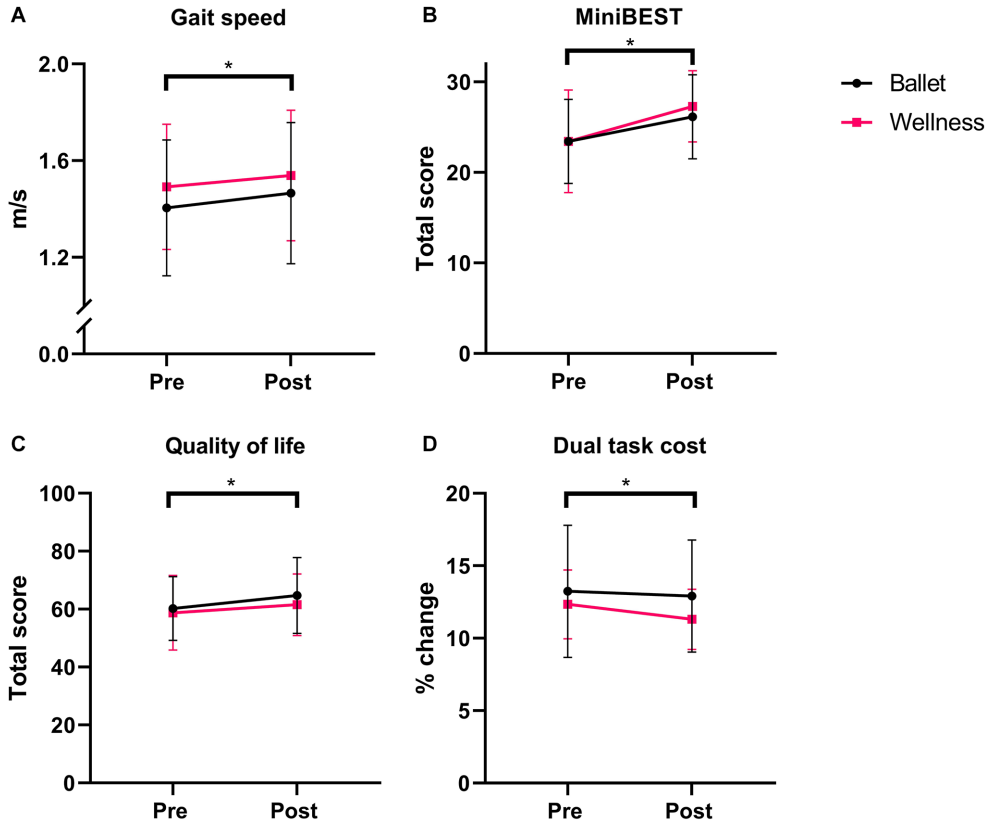

FIGURE 1
Key results pre- to post-intervention between groups. **(A)** Gait speed in 2MWT. **(B)** Mini-BESTest. **(C)** SF-36. **(D)** Dual Task Cost. * Indicates significance at $p < 0.05$.

reduced fall risk (Alqahtani et al., 2017; Omaña et al., 2021). Surprisingly, ballet participants had no better outcomes on static balance than wellness participants; however, this does confirm past findings that in-person ballet classes did not significantly alter postural stability during static poses (Weighart and DiPasquale, 2020). In previous work, this was attributed to an over-reliance on holding onto a ballet barre during class, which may not sufficiently challenge proprioceptive systems and therefore not alter performance on free-standing balance tasks (Weighart and DiPasquale, 2020). As we did not control for holding onto equipment, this may explain our similar results.

The ballet intervention successfully reduced falls while the wellness intervention did not. This corroborates past evidence that group exercise programs reduce falls whereas knowledge-based, educational interventions designed to reduce falls do not (Gillespie et al., 2021). The reduction of falls among ballet participants suggests that even small improvements in various domains of mobility and postural control may make a difference in everyday fall risk.

Both groups improved quality of life and spoke positively about the opportunity for virtual connection during a time of social isolation. As conversation time was built into the control intervention, wellness participants spent more time getting to know one another than ballet participants and may have developed bonds over shared experiences related to aging and health. Since the wellness class often showed parallel benefits to the ballet class, it is possible that the social outlet afforded during the wellness classes led to psycho-emotional benefits that translated to a global effect on motor outcomes.

Qualitatively, ballet participants reported higher class satisfaction and a stronger desire for the course to continue compared to the wellness participants. Their positive feedback emphasized the highly motivational nature of dance interventions, which may elicit deeper engagement than standard exercise (Earhart, 2009; Hwang and Braun, 2015). Participants in the ballet group also emphasized the importance of connecting creatively with other women, which highlights the interconnectedness of psycho-social–emotional wellbeing, artistic expression, and mobility (Kyrdalen et al., 2019). Lastly, they indicated that increasing mobility through engaging, expressive means gave them a sense of agency over both their physical and mental health. Such comments parallel a recent report that suggested that "the joyful, social, creative and expressive elements of dance are perhaps the precise reason for its efficacy within health contexts" (Introducing "Dance for Health", 2020). Taken together, the success of the ballet intervention from the participants' viewpoint further highlights the importance of considering psychosocial benefits of group movement-based interventions.

Several limitations to this study should be noted when interpreting the results. The high dropout rate reduced our sample size. The positive outcomes in the exit questionnaires could have been biased because they reflected the views of those who remained in the study. We chose the wellness class as a control intervention to provide similar social and attentional interactions but without a movement

component. The control intervention did not involve movement so we cannot know how ballet classes would compare to other forms of exercise. Future studies could compare the ballet intervention to different movement-based interventions, but that was not the goal of this initial study. Lastly, some of the significant changes we saw were small and may not be clinically relevant.

5 Conclusion

This study is among the first to explore the effects of virtual ballet as a therapeutic intervention for older women. The results highlight the importance of social interaction as a key component when developing future interventions to target physical, mental, and psychosocial wellbeing in older adults, as well as the enjoyability of dance relative to other approaches. Future work should compare the effects of virtual and in-person movement classes, while accounting for the interaction between multiple domains related to brain and body health.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by Washington University School of Medicine Institutional Review Board. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

EH: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. AH: Investigation, Writing – review & editing. LT: Investigation, Writing – review & editing. SB: Investigation, Writing – review & editing. GE: Conceptualization, Funding acquisition, Investigation, Methodology, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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Brazilian dance self-perceived impacts on quality of life of people with Parkinson's

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Background: Parkinson's disease (PD) causes several motor and non-motor symptoms, resulting in negative impacts on physical, mental, emotional, and social aspects of people with PD quality of life. Dance has been considered as a potential non-pharmacological intervention to improve people with PD motor and non-motor symptoms, thereby enhancing quality of life.

Purpose: To analyze the self-perceive impacts of Brazilian Dance on the quality of life (physical, mental, emotional, and social) of PwPD, both before and during the COVID-19 pandemic.

Methods: Fourteen participants from the "Dança & Parkinson" project were included in this qualitative study. Data collection instruments consisted of a profile and personal data sheet; assessment of accessibility to the online dance classes; Telephone Montreal Cognitive Assessment by phone call; and semi-structured interview conducted through ZOOM video call. The participants characterization data were calculated using mean, standard deviation, and percentages with the Excel Program version 2013. Qualitative data was analyzed using the Thematic Analysis technique in the Nvivo, version 8.0, qualitative analysis of text, sound, and video program.

Results: The participants reported facing various challenges in dealing with PD, which negatively impact their quality of life. However, their resilience, acceptance, and dedication to treatment play an important role in coping with the issues related to the disease. Brazilian dance, both in-person before the COVID-19 pandemic and online during the pandemic, led the participants to perceive improvements in physical, mental, emotional, and social aspects of quality of life.

Conclusion: The Brazilian dance appears to have a positive impact on the physical, mental, emotional, and social aspects of the participants' quality of life, both before and during the COVID-19 pandemic.

KEYWORDS

parkinsonian disorders, therapy through dance, quality of life, social isolation, COVID-19

1 Introduction

Parkinson's disease (PD), a neurodegenerative, chronic, progressive, and multifactorial condition, is currently the fastest-growing neurological disorder worldwide (Poewe et al., 2017; Simon et al., 2020). People with PD (PwPD) experience motor and non-motor symptoms, caused by the death of dopaminergic neurons in the substantia nigra of the basal ganglia (Poewe et al., 2017; Balestrino and Schapira, 2020). As PD progresses, PwPD face diminishing functional independence, reduced well-being and self-esteem, difficulties in performing daily activities, and limitations in social participation, all of which negatively impact their quality of life (QoL) (Martinez-Martin, 2017; Valcarenghi et al., 2018; Vescovelli et al., 2018; Kuhlman et al., 2019; Verity et al., 2020).

Engaging in complementary non-pharmacological interventions is important for preserving motor and cognitive skills, and helps minimize the impact of PD on QoL (Martinez-Martin, 2017; Donley et al., 2019). Several studies have shown that dance is an accessible non-pharmacological intervention (Emmanouilidis et al., 2021) that promotes various motor and non-motor benefits, for instance, improvements in gait and functional mobility (Delabary et al., 2020), as well as in cognitive domains such as executive function (Kalyani et al., 2019), contributing to improved QoL in PwPD (Hackney and Bennett, 2014; Holmes and Hackney, 2017). However, there is no consensus in the literature regarding the effects of dance on PwPD QoL, indicating varying or inconclusive results. Some systematic reviews show significant improvements in overall QoL of PwPD (Shanahan et al., 2015; Carapellotti et al., 2020), while others do not (Delabary et al., 2018; Ismail et al., 2021; Zhou et al., 2021).

Quality of life is a comprehensive concept influenced by an individual's physical health, psychological state, level of independence, social relationships, and their connection to significant aspects of their environment (WHOQOL Group, 1993; Stocchi et al., 2014). Therefore, any assessment of QoL in PwPD should be subjective, individualized, multidimensional, and consider the person's self-perceived social, psychological and physical condition in relation to the disease (Martinez-Martin, 2017). Since QoL is a multifaceted concept with a unique meaning for each individual, relying solely on quantitative assessments can inhibit a thorough understanding of this concept, this being a limitation in several studies on the effects of dance on the QoL of PwPD (Delabary et al., 2018; Ismail et al., 2021; Zhou et al., 2021). Nevertheless, studies using a qualitative approach to analyze the impact of dance on the QoL of PwPD have demonstrated improvements in: social participation (Zafar et al., 2017); self-confidence and participation in activities of daily living (Holmes and Hackney, 2017); body control and awareness, and motor symptoms (Beerenbrock et al., 2020); and the achievement of new ways of moving through experimentation and adaptation (Hulbert et al., 2020). However, according to the authors' knowledge, no studies has analyzed the self-perceived impacts of Brazilian Dances on the QoL of PwPD, using a qualitative approach.

In 2020, the decline in physical and social activities due to the COVID-19 pandemic had a significant detrimental effect on the PwPD QoL (Subramanian et al., 2020). This was shown in deterioration of motor symptoms, such as increased rigidity, tremors, gait difficulties, and non-motor symptoms (Brown et al., 2020; Subramanian et al., 2020), including mood swings, cognitive issues, fatigue, anxiety, depression, and fear of death (Brown et al., 2020; Haas et al., 2022; Moratelli et al., 2022). Online non-pharmacological interventions (Shalash et al., 2021), including dance classes, emerged as important tools to mitigate the negative effects of the pandemic on this population (Bek et al., 2021; Morris et al., 2021; Delabary et al., 2022; Walton et al., 2022).

Therefore, gaps in the current literature center around the need for more studies employing qualitative methodological approach, conducting a comprehensive exploration about the various aspects of PwPD QoL influenced by different dance genres, and to understand the impacts caused by the COVID-19 pandemic. Thus, this study aims to analyze the self-perceive impacts of Brazilian Dance on the quality of life (physical, mental, emotional, and social) of PwPD, both before and during the COVID-19 pandemic.

2 Materials and methods

2.1 Study design

This is a qualitative study approved by the Ethical Committee of the School of Physical Education, Physical Therapy and Dance at the Federal University of Rio Grande do Sul (CAAE 33547920.9.0000.5347). All the participants signed a consent form, and the study followed the Consolidated criteria for reporting qualitative studies (COREQ) and Standards for Reporting Qualitative Research (SRQR).

2.2 Participants

The participants were: people with a clinical confirmed diagnosis of PD, according to the London Brain Bank Criteria (National Collaborating Centre for Chronic Conditions, 2006), undergoing medical treatment for PD for at least 1 year, with regular use of anti-parkinsonian drugs; both sexes; ≥50 years old; staging between 1 and 3 of the Hoehn and Yahr Scale (H&Y), able to walk independently; who participated in the "Dance & Parkinson" project of the Federal University of Rio Grande do Sul before the COVID-19 pandemic, and continued to participate in the "Dance & Parkinson at home" online project, during the pandemic. Those with risk factors, such as recent surgery, deep brain stimulation, and other associated neurological or chronic diseases were excluded.

All the participants in the "Dance & Parkinson's" project who, during the pandemic, took part in the online classes were invited to participate in the study. They were invited to participate in the study via WhatsApp, and all accepted. Thus, 14 PwPD (9 women and 5 men) were enrolled in the study and assigned names of colors to maintain their anonymity. The participants' demographic and clinical characteristics are presented in Table 1.

2.3 "Dance & Parkinson's" project

The community and research project "Dance & Parkinson's" for the School of Physical Education, Physiotherapy and Dance (ESEFID) at the Federal University of Rio Grande do Sul (UFRGS), Brazil, was

TABLE 1 Participants' demographic characteristics.

Participant	Duration of interview	Sex	Declared ethnicity	Age (years)	Time of PD (years)	Time of dance practice (years)	H&Y	Cognition (T-MoCa)	Level of education (years)	Medication LED (mg/day)
Lilac	40 min	F	White	62	7	6	2	19	Higher Education	Prolopa 400
Turquoise	72 min	F	White	56	9	2	3	22	Higher Education	Prolopa 800
Yellow	33 min	F	White	76	4	4	3	16	No level	Prolopa 500
Orange	42 min	F	White	74	6	4	2.5	18	High School	Prolopa 300
Red	62 min	F	White	87	8	6	3	15	No level	Prolopa 400
Navy Blue	47 min	M	White	67	2	2	2	22	High School	Prolopa 600
Mustard	42 min	M	White	70	5	3	1	21	Higher Education	Prolopa 200
Light Green	30 min	F	Black	67	3	3	3	15	No level	Prolopa 300
Brown	29 min	M	White	67	3	2	2.5	16	High School	Prolopa 400
Violet	32 min	F	White	85	24	3	1.5	21	High School	Prolopa 800
Burgundy	40 min	F	Black	68	14	6	3	18	High School	Cardiodopa 1,200
Dark Green	46 min	F	White	66	6	3	3	15	No level	Prolopa 800
Pink	38 min	F	White	67	6	3	3	19	High School	Prolopa 800
Gray	42 min	M	White	83	6	3	3	16	Elementary School	Prolopa 300
Mean	42.5	NA	NA	71.1	7.4	3.6	2.6	18.1	NA	607.1
SD	11.9	NA	NA	8.9	5.7	1.5	0.7	2.6	NA	239.9
%	NA	64% F 36% M	86% W 14% B	NA	NA	NA	NA	NA	21% HE 43% HS 7% ES 29% NL	7% LC 93% P

Parkinson's disease (PD); minutes (min); Hoehn & Yahr (H&Y) scale; Telephone Montreal Cognitive Assessment Test (T-MoCA); Standard deviation (SD); Not applicable (NA); Female (F); Male (M); White (W); Black (B); Higher Education (HE); High School (HS); Elementary School (ES); No level (NL); Levodopa-Carbidopa (LB); Prolopa (P). Levodopa equivalent daily dose (LED) (Tomlinson et al., 2010).

created in 2016. The project is led by an Associate Professor in Dance and organized by a group of undergraduate and post-graduate students. Since 2016, the "Dance & Parkinson's" project has promoted dance classes, inspired by the Brazilian rhythms (Haas et al., 2018; Peyré-Tartaruga et al., 2022), designed to provide qualitative improvements in the physical and mental health of PwPD. Figure 1 presents the project timeline from March 2016 to December 2021.

From March 2016 to December 2019, the Brazilian dance classes were performed in person, 1-h twice a week at the ESEFID. In March 2020, the COVID-19 pandemic was officially declared in Brazil, social isolation was adopted as a preventive measure, and the project was adapted for the online format. The participants attended online dance classes, with asynchronous and synchronous learning experience (58). From April to July 2020, the project offered recorded dance classes on a dedicated Youtube Channel.[1] During the second half of 2020, a synchronous learning experience with live-streamed, weekly dance classes, involving small groups was offered via WhatsApp Video Call or Facebook Messenger Room (58). In March 2021, the project offered synchronous learning experience with 1-h online dance classes twice a week through ZOOM platform.

The in-person and online Brazilian dance classes were structured according to Haas et al. (2018) and Delabary et al. (2022) as shown in the Figure 2.

2.4 Instruments

Before interviewing, during an initial phone call, anamnesis was carried out to characterize each participant's demographic characteristics, and the Telephone Montreal Cognitive Assessment (T-MoCA) were applied to assess the participant's cognitive level (Pendlebury et al., 2013). In addition, each participant was asked to send a certificate from their neurologist with the Hoehn & Yahr scale (H&Y) staging.

A semi-structured interview with open-ended questions was developed based on a literature review regarding the PD characteristics and impacts and the benefits of dance practice on PwPD QoL. At the beginning and the end of the semi-structured interview were asked. The main body of the interview focused on four primary categories: (1) Living with Parkinson's; (2) Self-perceived QoL; (3) Self-perceived impacts of the in-person Brazilian dance classes; and (4) Self-perceived impacts of the online Brazilian dance classes (Table 2). Within these primary categories, three main subcategories were created: (1) Physical; (2) Mental and emotional; and (3) Social.

1 https://www.youtube.com/channel/UCILPKVSA-7LygQ-zAh5wR3A

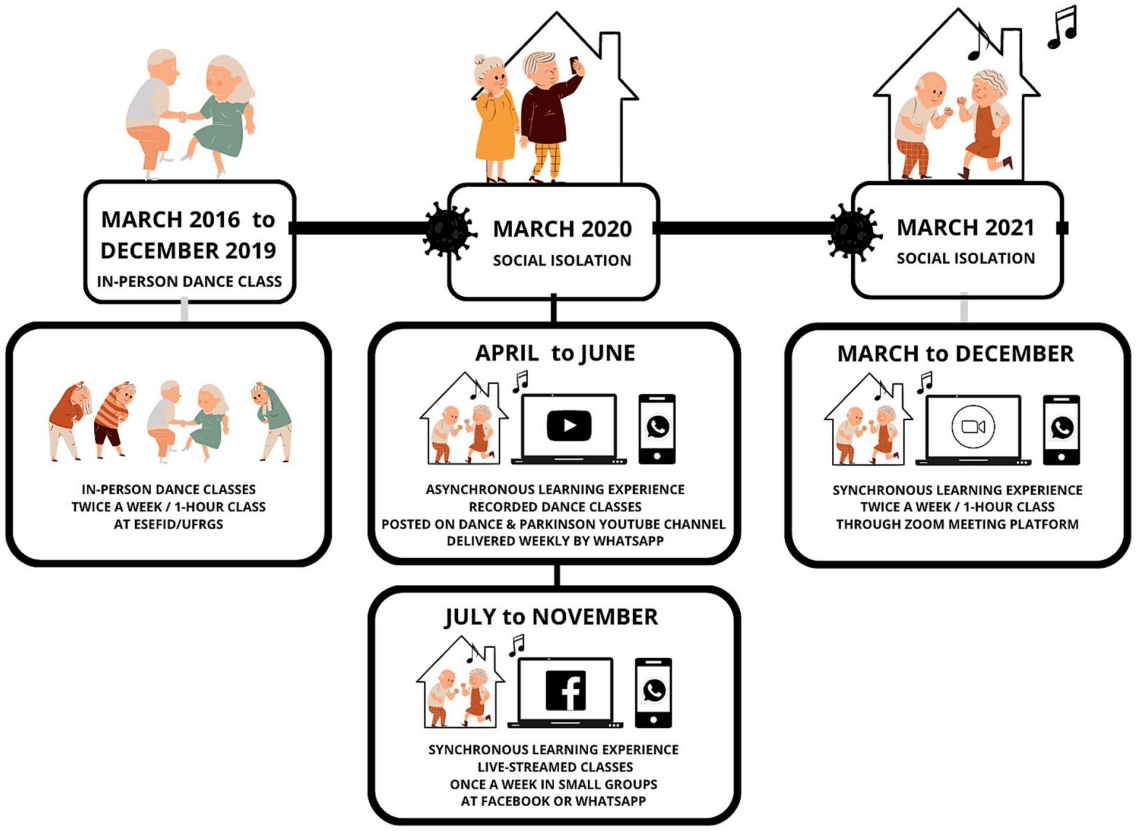

FIGURE 1
"Dance & Parkinson's" project timeline form March 2016 to December 2021.

The interviews were conducted on the ZOOM platform by a dance teacher and researcher, and lasted 43 ± 12 min on average. All the semi-structured interviews took place during the "ON" state of the anti-parkinsonian medications, up to 2 h after taking the medicine.

2.5 Data analysis

The semi-structured interviews were conducted and recorded on the ZOOM platform. Later, they were transcribed faithfully by dance researchers, preserving the original words and reviewed by the participants. The content of the interviews was then analyzed to extract meaning and gain insight into the collected data to address the research questions.

The Qualitative Text, Sound, and Video Analysis program, Nvivo version 1.5.1, was used to organize, code, store, and analyze the qualitative content. In the data analysis, we implemented a detailed coding process to systematically analyze text data, ensuring a comprehensive exploration of the participants' self-perceived impacts of Brazilian Dance on their QoL. To enhance the reliability of the data analysis, an analyst independently coded a subset of the data, aiming to mitigate potential errors and strengthen the robustness of our findings and ensuring the reliability of Nvivo software by emphasizing proper coding practices, mitigating errors, or misinterpretation risks in the qualitative content analysis. During the coding process, the interviews were read and analyzed, using the criteria of the Thematic Analysis method (Braun and Clarke, 2006), and, as we previously mentioned, four primary categories were identified (Live with Parkinson's; Self-perceived QoL; Self-perceived impacts of the in-person Brazilian dance classes; and Self-perceived impacts of the online Brazilian dance classes). The results are organized according to these four primary categories using interview excerpts, while subcategories are grouped in tables, and subdivided into subthemes, considering physical, mental and emotional, and social aspects of QoL.

The qualitative analysis was conducted in the original language, Brazilian Portuguese. To present these results, relevant excerpts from the interviews were translated to English. Back-translation process, involving a bilingual researcher and a proof-reader English speaker, was used to enhance the accuracy of translation and minimizing the risk of errors or misinterpretation.

Statistical analysis (mean, standard deviation, and percentage) are used to present the participants' demographic characteristics (Table 1). The analysis was carried out using the Excel Program, version 2013.

3 Results

3.1 Living with Parkinson's

The participants shared their experiences, highlighting the difficulties they faced upon receiving a PD diagnosis and the subsequent challenges in adapting their daily lives and routine. Brown expressed the inevitability of PD having a significant impact: *"There's no way something like this could pass by without having an impact, right?."* Yellow described

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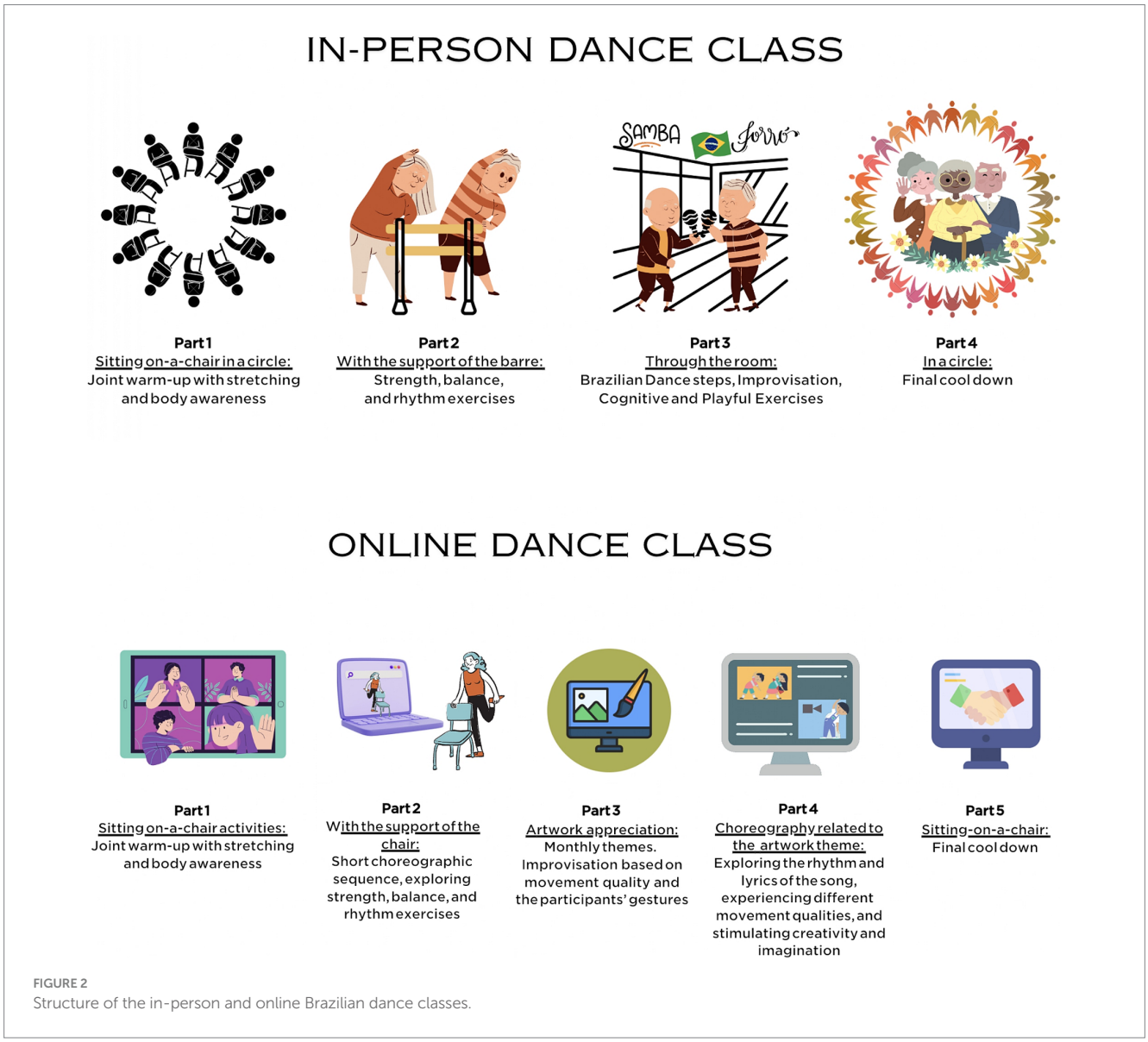

FIGURE 2
Structure of the in-person and online Brazilian dance classes.

the hardships of living with Parkinson's, affecting communication and mobility: *"It's bad, it's hard to have Parkinson's. So, it's hard to talk, to move, people have to be patient to listen to you […]. Everything became more difficult, communication, movements. Everything."* Burgundy emphasized the lifestyle changes and the constant reminder of the disease: *"This changes your rhythm of life, your routine, because you are always thinking about the medicine, even if you do not want to think about the disease, you have to remember to take the medicine on time, you have to take care of your diet with the medicine […] you have to know how to let go, because otherwise you get paranoid. That's the truth."*

Some participants also mentioned the sense of losing their essence and not feeling like themselves anymore. Turquoise reflected on this loss of identity: *"I think it is one of the worst feelings because you come to believe that you are no longer yourself."* Burgundy expressed the complications of the disease, leading to a sense of not being the same person anymore: *"It's complicated, right? It's depressing because you are no longer the same person, right? It's not 100 % your way of being… walking, doing this or that …"*

Many participants highlighted the importance of accepting the reality of Parkinson's as a part of life. They emphasized the need to confront the disease head-on rather than dwelling on self-pity. For example, Lilac stated: *"As soon as Parkinson's appeared, I was left with no direction… But then you get over it, you take it as a normal thing… There's no point in me crying in the corner because I have Parkinson's."* Turquoise added: *"You learn to try to get around it and see the other side! […] taking it in a sporting way or it's too sad!."*

The participants stressed the significance of staying positive in the face of adversity. They refused to surrender to the disease and maintained an optimistic mindset: *"We cannot surrender, that's what I always think, the disease wants to take me down but I do not let it, so I think positively." (Burgundy); "I do not give up, I may not be very good, but I do not give up!" (Pink)*. Some participants found solace in accepting their condition as part of a higher plan, citing their faith in God: *"I accept things as they are… I think that things have to be this way, and we have to accept it, it is God's will, so, I am catholic, and I accept everything." (Yellow); "I am not ashamed of my tremor, I am not ashamed of having the disease because God gave it to me and I have to put up with it, right?" (Burgundy).*

For certain participants, a pragmatic approach involved acknowledging that certain things are beyond their control. They

TABLE 2 Semi-structured interview questions.

Topic/categories	Questions
Beginning	- Tell me a little about your experience in the "Dance & Parkinson" project. Why did you join the project? What were your expectations before joining? And what are your expectations now with the online dance classes? - Tell me a little about your daily routine before the pandemic and now during the pandemic.
Self-perceived QoL (physical, mental/emotional and social aspects)	- What is QoL for you? - Do you perceive any impact of PD: on your activities of daily living (ADLs) and functional independence? On your self-esteem? On your sense of well-being? On your social life prior to or during the COVID-19 pandemic?
Self-perceived impacts of the in-person Brazilian dance classes (physical, mental/emotional, and social aspects)	- Do you perceive any impact of in-person dance classes: on your ADLs and functional independence? On your self-esteem? On your sense of well-being? On your social life prior to the pandemic?
Self-perceived impacts of the online Brazilian dance classes (physical, mental/emotional, and social aspects)	- And now, during the pandemic, do you perceive any impact of online dance classes: on your ADLs and functional independence? On your self-esteem? On your sense of well-being? On your social life?
End	- Do you have any other information that you want to share? Any other questions that I have not asked, that you want to talk about?

chose to accept their situation and adapt to it: *"I'm a very realistic person, and I accept things […] I accepted my Parkinson's well." (Violet); "If it has to be, it has to be, and that's it. Just accept it and get used to it." (Mustard).*

The participants also recognized the importance of actively seeking ways to improve their quality of life. They assumed responsibility for their well-being and treatment, striving to make the most of their situation: *"So, I have to try to do my best, look for alternatives to improve my quality of life. […] While there is no cure, we have to live with it and try to do the best we can." (Lilac); "I have Parkinson's, and I will do my best to live as well as I can and not to give my children and family too much trouble." (Orange).*

The participants highlighted various physical, mental, emotional, and social challenges in their daily lives, all stemming from the limitations imposed by PD. These challenges had a profound impact on their social interactions and QoL. Despite experiencing the physical, mental, emotional, and social impacts of PD, resilience and acceptance were common themes among nearly all the participants. These two qualities appeared to be essential for coping with the challenges posed by the disease and the necessary adjustments in their lives. The self-perceived impacts of living with Parkinson's, categorized into physical, mental and emotional, and social aspects are summarized in Table 3.

3.2 Self-perceived QoL

When asked about their understanding of the meaning of QoL, some participants reported that QoL changes throughout the stages of life and according to the context in which the person is situated: *"It depends a lot on the phase of life that you are in. As a child, it's one type, in adolescence, it's another, in adulthood, it's a different again. In mature life too, it's different" (Violet).*

Considering the participants' social-economic contexts, some emphasized the importance of the economic conditions, access to resources, and social support, especially from family and friends: *"Quality of life is also subjective. It depends on age, social conditions, and educational background… My experience with Parkinson's tells me the understanding and support of my family and all my friends are indispensable…" (Violet); "It's having someone who cares about you…" (Turquoise).*

Many participants highlighted health, the 'will to live,' and happiness as important factors in their QoL: *"It's having health and the disposition to face the challenges that life presents" (Violet); "It's about having good health, feeling pleasure" (Yellow); "I think it's about being happy, being able to smile" (Turquoise); "It's having health, experiencing pleasure in life, and being happy… I believe it's crucial for us to be happy and have the will to live" (Red).*

Independence and the freedom to do what they want were also aspects present in many statements: "*For me, it means having maximum independence in my life, minimal physical and emotional limitations, and the ability to do things… to be physically well" (Mustard); "Being able to do the things that you want to do…" (Brown); "For me, it's about being able to go out, attend church, work, and be independent… That, to me, is quality of life. Not staying idle and wasting time" (Dark Green); "It's about being able to do the things you enjoy, even if it's at a slower pace" (Navy Blue).*

Considering the chronic nature of the disease and the wisdom acquired throughout life, some participants reflected on the importance of actively seeking QoL, valuing the little things in life, and being flexible in dealing with problems: *"It's about trying to make each day a good day, choosing it, and striving to make it happen" (Lilac); "Being able to participate in things in the best way you can…" (Navy Blue); "It's about having tranquillity, knowing how to appreciate the good times and having the balance to face and resolve the not-so-good ones. All of these contribute to our quality of life, I believe" (Violet).* The Figure 3 illustrates the self-perceived concept of QoL.

TABLE 3 The self-perceived impacts of living with Parkinson's.

Subcategories of the impacts of living with Parkinson's		Lilac	Turquoise	Yellow	Orange	Red	Navy Blue	Mustard	Light Green	Brown	Violet	Burgundy	Dark Green	Pink	Gray	*n*	%
Physical	Slowness	x		x			x	x	x		x			x		7	50
	Rigidity	x		x	x	x	x	x		x		x	x	x		**10**	**71**
	Tremor	x				x	x				x	x			x	6	43
	Balance Changes					x		x	x		x					4	29
	Dyskinesia											x				1	7
	Pain				x	x					x	x				4	29
	Tiredness	x				x		x			x		x	x		6	43
	Difficulty performing activities of daily living		x			x			x	x	x	x	x	x		8	57
	Decreased functional independence		x		x	x			x							4	29
	Gait changes		x	x				x	x		x		x	x		**7**	**50**
	Fine motor difficulties		x			x							x			3	21
	Weakness		x					x	x	x	x	x	x	x		**7**	**50**
	Changes in the digestive system						x	x								2	14
	Postural Changes					x						x		x		3	21
	Loss of spontaneity												x			1	7
	Freezing of Gait												x			1	7
	Fear of falling	x	x		x	x					x			x		6	43
	Falls		x		x	x			x				x	x		6	43
	Decrease in physical well-being		x		x	x		x	x	x	x		x	x		**9**	**64**

(Continued)

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TABLE 3 (Continued)

Subcategories of the impacts of living with Parkinson's		Lilac	Turquoise	Yellow	Orange	Red	Navy Blue	Mustard	Light Green	Brown	Violet	Burgundy	Dark Green	Pink	Gray	*n*	%
Mental and emotional	Loss of Memory		x						x	x		x			x	5	36
	Feeling of incomprehension								x							1	7
	Distress and Despair		x										x			2	14
	Feeling of helplessness	x	x			x										3	21
	Shame		x	x									x			3	21
	Indisposition			x		x										2	14
	Changes to the voice		x	x					x						x	4	29
	Difficulty expressing yourself			x					x						x	3	21
	Sadness		x	x		x										3	21
	Lower self-esteem		x	x				x			x	x	x		x	**7**	**50**
	Less empowerment		x					x					x			3	21
	Impotence		x					x					x		x	4	29
	Sleep disorders					x				x	x		x			4	29
	Concerns about the future	x	x		x					x		x	x		x	**7**	**50**
	Decreased emotional well-being		x		x	x	x	x	x	x	x		x			**9**	**64**
	Feeling of not being yourself		x									x				2	14
Social	Fear to go out				x	x			x							3	21
	Lack of social interaction			x		x			x	x					x	5	36
	Inability to work		x			x							x			3	21
	Feeling people are staring at me			x			x				x	x	x			5	36

The bold values emphasize the responses with higher percentages.

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3.3 Self-perceived impacts of the in-person Brazilian dance classes

The participants highlighted the significance of their involvement in the "Dance & Parkinson" project in their lives: *"This project improves the quality of life for us a lot" (Red); "The classes are enjoyable!" (Yellow); "I felt much, much, much better being part of the Dance & Parkinson's project" (Violet); "And it's a place where you meet people with the same problem as you, and everybody smiles, everybody plays and dances." (Turquoise); "I wanted to shout to the world: Everyone who has Parkinson's should participate in this project, you know?" (Lilac).*

They shared their thoughts on the dance experience*: "Dance taught me a lot of things, still teaches me, to move, an arm this way, a leg that goes that way, and we do it" (Burgundy); "It's the rhythm, it's the movement, transforming the sound of the music into a body movement." (Mustard);* They also reflected on the role of dance in humanity*: "I think that dance has a special magic […] I think dancing is fundamental. […] I think that if everyone in the world danced, the world would be a much better place" (Turquoise).*

The participants mentioned various positive physical, mental, emotional, and social impacts of the "Dance & Parkinson" project: *"Without a doubt, the dance classes are contributing in all aspects, physical and social, through gestures, affection, words. In physical and emotional well-being,… just getting a good morning like this with a smile, I've already won my day" (Lilac); "I feel much better. I do not know… the classes take away all that sickness thinking of things like that… I feel good!" (Red); "I feel the influence of the dance classes in social life, in daily life […] Besides the physical part, obviously, the mobility, the agility, the balance" (Violet).* All impacts reported by the participants were summarized in Table 4.

Furthermore, all the participants underscored the importance of socialization and the sense of belonging provided by the group: *"The group brings vibrancy, joy, more energy…" (Lilac).* They emphasized the friendships they found: *"When we met and talked, it was so good! That's why I liked it! We made other friends, we talked… even about the disease…" (Red);* The coexistence with the group motivates them to make more and more effort: *"This thing of the group, the motivation, of 'go, go, go' was the most important thing for me" (Dark Green); "The participation in this group gave me a certain encouragement… Not to let the disease take over … To fight against it…" (Mustard).*

In this context, the participants highlighted the positive aspect of finding a group of peers, where they felt free to talk and exchange experiences openly: *"Noticing people with the same problem as mine, sometimes worse than me, that helped me a lot to live with my disease" (Dark Green); "They are all the same. Everyone has difficulties, they understand everything…" (Yellow); "We speak the same language there … You feel good there… I think there is a release…" (Burgundy).* This coexistence with peers helps lessen the feeling of loneliness: *"We see that in the group we are not alone, you know? There are many people with the same problem. So there we get comfort" (Lilac); "There we feel inserted in the world and not isolated" (Violet); "The interaction with the teachers and with the other participants I think is very important because before it was me with Parkinson's … I felt alone. And this interaction allowed us to realize we are not alone. And we feel part of the group too" (Turquoise).*

Many participants perceived an immediate positive effect during and after the in-person Brazilian dance class, reporting that they left the class better than they had arrived: *"I feel that whenever I left the class there, I felt much better than when I arrived… I came out with a lot of energy, a lot of disposition" (Mustard); "The state of mind improves, and the physical condition improves, and I feel more… I do not know if it's the muscles that are more warmed up, stretched, I do not know what works, but it improves, I know it does!" (Turquoise); "The classes were good for my body and soul" (Violet).*

They perceived physical improvements: *"I started to feel more energy to do things. The energy is much better. And things start moving again!" (Turquoise); "The sensation we have after we finish the classes seems like you feel relieved, lighter…" (Navy Blue); "We had fun! I came out of there light!" (Dark Green).*

In addition to the immediate effects, participants perceived improvements over the years they have been participating in the project. Some pointed out physical impacts: *"I feel more agile. I think that dance helps me to be well… I can continue walking…" (Pink); "I went back to work, I went out again, talked more. I think it made me feel more at ease, right? And with the hope of getting better and better. So I felt much more confident because of that" (Dark Green).* Also, mental and emotional improvements were noted: *"I started attending, I started to have more confidence in myself… It increased more my self-confidence, the self-esteem" (Dark Green); "My clothes were always black or little brown… Suddenly, I started to arrive in colourful clothes, and that was drawing attention" (Lilac).*

The possibility of participating in some activities promoted the perception of empowerment and increased the self-esteem of some participants: *"I had never gone on stage to dance, right? And in the project, we even went on stage to dance. Everyone gave us a standing ovation… We prepared ourselves, we bought fabric, we made skirts, we dressed up, you know? Beautiful ones, you know? And that lifts our ego…" (Lilac); "We think we will not be able to do anything, but we dance things that we did not even think of dancing, do movements that we thought we would not be able to do!… We still can!… The dance class and the interaction, what we can do physically, improves our state of mind a lot; it gives us personal empowerment" (Turquoise).*

Another important aspect highlighted by the participants was the engagement and attendance in classes: *"The project was something that I always did with pleasure, right? So I think in the years I participated there, I do not remember missing a single day" (Mustard); "It's hard for me to leave early in the morning, take the bus, in the cold, in the rain, but we never stop going" (Burgundy).* Some participants mentioned their motivation and preparation for class: *"The joy every day that we have class is very great; we get up with much more willpower" (Violet); "It was the best. I could not wait for the classes to happen because we would meet, wait for one or the other, you would arrive happy and leave even happier" (Navy Blue).*

3.4 Self-perceived impacts of the online Brazilian dance classes

The COVID-19 pandemic and the social isolation experienced by the participants disrupted their lives, paused their activities, and changed their routines: *"It shook me when we had to stay still, it shook my head and my body, because we were just inside the house." (Red); "Yeah, 24 h inside the house! You wake up and have breakfast, sit down and read the newspaper, watch TV, then do not have anything else to do.*

TABLE 4 The self-perceived impacts of the in-person Brazilian dance classes.

Subcategories of the impacts of Brazilaian dance classes		Lilac	Turquoise	Yellow	Orange	Red	Navy Blue	Mustard	Light Green	Brown	Violet	Burgundy	Dark Green	Pink	Gray	n	%
Physical	**Reduced stiffiness**	x	x		x			x			x	x		x		**7**	**50**
	Feeling of lightness and fluidity in the movements		x				x	x		x		x				5	36
	Agility		x			x					x			x		4	29
	Less rigidity		x					x			x	x		x		5	36
	Less pain		x			x										2	14
	Improved balance	x			x			x			x	x			x	**6**	**43**
	Disposition	x	x			x		x			x					5	36
	Easier execution of activities of daily living		x	x		x					x	x	x			**6**	**43**
	Improved motor coordination							x						x		2	14
	Improved stamina										x					1	7
	Easier to initiate movement		x					x		x						3	21
	Improved fine motor skills		x										x			2	14
	Improved body awareness											x				1	7
	Improved gait											x	x	x	x	4	29
	Improved physical well-being	x	x		x	x		x	x	x	x	x	x		x	**11**	**79**

(Continued)

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TABLE 4 (Continued)

Subcategories of the impacts of Brazilaian dance classes		Lilac	Turquoise	Yellow	Orange	Red	Navy Blue	Mustard	Light Green	Brown	Violet	Burgundy	Dark Green	Pink	Gray	n	%
Mental and emotional	**Happiness**	x	x		x		x				x	x	x		x	**8**	**57**
	Enjoyment		x		x		x	x			x	x	x		x	**8**	**57**
	Improved mood and liveliness	x	x				x	x				x		x		6	43
	Increased desire and motivation		x		x			x			x	x	x			6	43
	Increased energy and disposition	x	x			x		x			x	x				6	43
	Feeling of pleasure		x	x	x		x	x			x	x				**7**	**50**
	Feeling of freedom		x													1	7
	Feeling of lightness						x	x	x				x			4	29
	Fewer thoughts about illness					x			x							2	14
	Better able to face the difficulties of the disease		x					x		x		x				4	29
	Exercising memory	x				x	x									3	21
	Improved self-esteem	x	x		x	x	x						x			6	43
	Feeling of empowerment	x	x			x	x						x	x		6	43
	Feeling of self-confidence		x				x						x			3	21
	Improved emotional well-being	x	x		x	x	x	x	x	x	x	x	x		x	**12**	**86**

(Continued)

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TABLE 4 (Continued)

Subcategories of the impacts of Brazilaian dance classes		Lilac	Turquoise	Yellow	Orange	Red	Navy Blue	Mustard	Light Green	Brown	Violet	Burgundy	Dark Green	Pink	Gray	n	%
Social impacts	**Friendship**	x	x		x	x	x	x	x		x	x	x	x	x	**12**	**86**
	A greater sense of living										x		x	x		3	21
	Increased participation in social activities	x	x	x		x		x	x	x	x	x	x	x	x	**12**	**86**
	Increased communication												x			1	7
	Participating in dance performances	x				x						x				3	21
	Possibility of returning to work												x			1	7
	Feeling of belonging	x	x	x			x	x	x	x	x	x	x	x		**11**	**79**
	Possibility expressing yourself		x	x		x			x			x	x			6	43
	Possibility to interact with peers	x	x	x	x	x	x	x	x	x	x	x	x	x		**13**	**93**
	Feeling the support of the group		x						x			x	x			4	29
	Feeling of comprehension in the group			x		x			x			x	x			5	36

The bold values emphasize the responses with higher percentages.

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Then you become very idle, you cannot go out, you know, it's dangerous…" (Gray).

In some reports, the participants lamented the impossibility of having in-person dance classes in the "Dance & Parkinson" project: *"I am very sad the pandemic happened, that we had this isolation and did not continue the classes in-person…" (Violet); "We danced face-to-face and suddenly we had to stop that, and of course, that caused frustration…" (Mustard); "I miss the colleagues, now in the pandemic." (Yellow); "It was an injustice to stop it, it was very good for me" (Gray).* And they perceived their PD symptoms worsened during social isolation: *"Until a few months ago, I was doing OK, and I was expressing myself well and I danced and did everything, went to the supermarket and now my symptoms are getting worse. […]" (Gray).*

About the online Brazilian dance classes during the pandemic, all the participants reported that they preferred in person classes, but were happy with the possibility of continuing to dance during social isolation: *"in person you vibrate more, your body corresponds better, right!" (Brown); "But I think it's better this way [online] than standing still." (Yellow); "It's different, but it's better than doing nothing." (Navy Blue).* The participants mainly point to the lack of physical presence: *"[…] it is not the same interaction as when we are live and in colour, there the interaction is much greater. […] The human being feels the relationship, it does not matter, we feel the relationship" (Turquoise).* And several participants refer to the challenges faced in the online dance: *"Now, for example, I'm at home watching them, or only watching the teacher from afar, in a little while, for example, the internet fails, the voice disappears, there is not the same motivation or quality for us" (Navy Blue).*

Despite the limitations and challenges, they reported some results: *"I feel that online classes are limited, but the same, it has its results, not so good than in person, but it has results." (Lilac); "It is quite different from the face-to-face project… but I will tell you, I spent a few days without dancing because I was injured, and I really missed it, I think it helps a lot so that we do not feel so far away from something that is so good for us, right?" (Orange).*

During the pandemic, the participants reported how online dance classes were part of their routine: *"I keep waiting for the class! I keep looking forward to it." (Turquoise); "on Monday and Wednesday, we have the appointment. I think that's important. […] The class is an incentive." (Dark Green); "We get ready at night to get up earlier to get organized for class […] We do it because we like it, because we want to participate, we adapt and want to be there, and we are on time, to make the internet work." (Navy Blue).*

They also reported positive effects perceived during and after the online dance classes: *"I feel very good after taking the virtual classes! […] I'll tidy up, wash the clothes I wore, and I'll put on some other clothes" (Red).* Even though it's only on a screen, the participants expressed the importance of seeing their peers in the synchronous classes: *"It's nice to see colleagues […] Online classes are very good, it's the way we can see, at least from a distance, all the teachers, all the students." (Violet); "When I can talk with someone, then I'm laughing by myself, you know? It always cheers me up…" (Lilac); "Given the longing we have for all the people, seeing each other on the screen improves us a lot." (Yellow); "To see if there is anything new, if everyone is here, to see each one's smile, what the teacher has to say, what the topic of the day is…" (Navy Blue).*

Table 5 summarizes the physical, mental, and emotional, and social self-perceived impacts of the online Brazilian dance classes during the COVID-19 pandemic.

4 Discussion

The purpose of this study was to analyze the self-perceived impacts of Brazilian Dance on the QoL (physical, mental, emotional, and social aspects) of PwPD, both before and during the COVID-19 pandemic. The participants reported a wide range of factors that impact their QoL, depending on their circumstances and life stage (Figure 2). They also asserted that dancing had positive impacts on physical, mental, emotional, and social aspects of their QoL, both before and during the COVID-19 pandemic.

PD is a multifactorial condition that can affect each person differently (Poewe et al., 2017). Therefore, it is important to understand how PwPD self-perceived the impacts of PD in their QoL. The participants perceived several negative physical, mental, emotional, and social impacts in their lives following their Parkinson's diagnosis. These findings align with existing literature, as PwPD often experience a range of motor and non-motor symptoms that affect their QoL (Poewe et al., 2017; Titova and Chaudhuri, 2018; Balestrino and Schapira, 2020). Regarding the physical aspects that negatively affect QoL, most participants mentioned rigidity, decrease in physical well-being, difficulty performing activities of daily living, among others. Regarding the mental and emotional impacts of PD on participants' QoL, the primary issues reported included decreased emotional well-being, lower self-esteem, and concerns about the future. These perceptions are in line with the literature (Kuhlman et al., 2019; Verity et al., 2020; Kavya et al., 2022). These impacts can led to a decline in professional and social activities, potentially leading to a withdrawal from their usual social roles (Perepezko et al., 2019).

The COVID-19 pandemic has had a profound impact on the routine of PwPD (Brown et al., 2020; Subramanian et al., 2020). The reduction in participation in physical and social activities, the cancelation of medical appointments, and social isolation have contributed to the worsening of PD severity and the intensification of both motor and non-motor symptoms, consequently reducing the QoL for PwPD (Brown et al., 2020; Haas et al., 2022; Moratelli et al., 2022). The participant's narratives emphasizing their ability to adapt to a new routine during the social isolation is align with the existing literature and underscore the detrimental impact of this abrupt change. In this context, engaging in online activities emerged as a crucial tool (Shalash et al., 2021), highlighting the significance of continuing online dance classes during the ongoing pandemic period (Delabary et al., 2022).

In terms of living with Parkinson's, the participants expressed a view consistent with existing literature that highlights the negative impact of self-perceived QoL among PwPD (Stocchi et al., 2014). The presence of both motor and non-motor symptoms is known to influence this perception negatively (Bock et al., 2022). The participants detailed various aspects of living with the condition and underscored the challenges associated with diagnosis, the necessary adjustments in daily life, and the feeling of no longer being one's true self. These findings align with

TABLE 5 The self-perceived impacts of the online dance classes.

Subcategories of the impacts of online dance classes		Lilac	Turquoise	Yellow	Orange	Red	Navy Blue	Mustard	Light Green	Brown	Violet	Burgundy	Dark Green	Pink	Gray	n	%
Physical	Reduced stiffiness	x	x				x			x	x					5	36
	Agility	x									x			x		3	21
	Less Rigidity		x								x	x				3	21
	Less pain		x													1	7
	Improved balance										x	x				2	14
	Disposition		x				x				x				x	4	29
	Easier execution of activities of daily living		x	x		x						x			x	5	36
	Improved motor coordination		x									x				2	14
	Improved gait		x													1	7
	Improved physical well-being	x	x	x	x				x	x	x	x	x	x		**10**	**71**
Mental and emotional	Happiness		x			x	x				x	x				4	29
	Improved mood and liveliness	x	x				x					x				4	29
	Increased desire and motivation		x		x		x						x	x	x	6	43
	Increased energy and disposition		x		x	x	x				x					5	36
	Feeling of pleasure		x	x				x				x				4	29
	Feeling of lightness						x									1	7
	Feeling safe		x								x					2	14
	Better able to face the difficulties of the disease and pandemic				x		x							x		3	21
	Enhanced memory	x					x					x				3	21
	Intellectual stimulus	x														1	7
	Improved self-esteem		x		x	x	x						x	x		6	43
	Feeling of empowerment	x	x										x			3	21
	Improved emotional well-being	x		x	x		x		x		x	x	x			**8**	**57**
Social	**Friendship**	x	x		x		x	x			x	x	x	x		**9**	**64**
	Feeling of belonging		x	x				x								3	21
	Possibility expressing yourself			x												1	7
	Possibility to see and interact with peers	x	x	x	x	x	x	x	x		x		x	x		**11**	**79**
	Relieve the loneliness			x	x		x				x					4	29

The bold values emphasize the responses with higher percentages.

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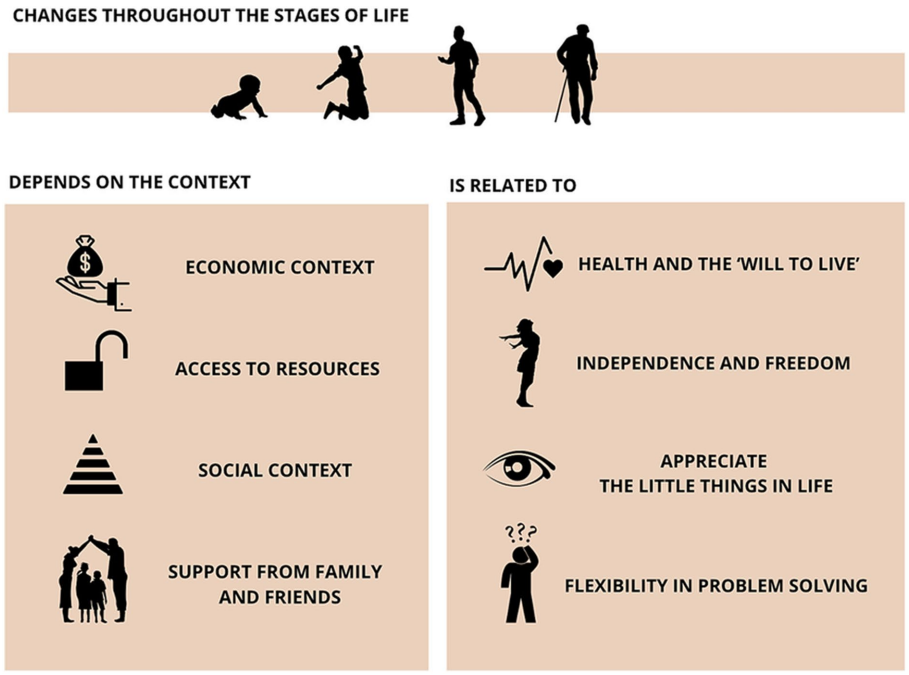

FIGURE 3
Self-perceived concept of QoL.

Valcarenghi et al. (2018), who emphasized that living with a chronic illness can profoundly affect one's life in numerous ways (Figure 3).

Given the chronic nature of PD and the wisdom that comes with life experiences, some participants reflected on the significance of resilience and acceptance in their pursuit of a higher QoL. They emphasized the need to adapt to their new reality, overcome challenges, and find joy in life's smaller moments. Although resilience cannot alter the severity of PD, it has been associated with increased optimism and an improved QoL (Gardenhire et al., 2019). It also correlates with reduced disability, apathy, depression, and fatigue (Robottom et al., 2012). Acceptance and adaptability have an important role in perceived life satisfaction, especially in the context of a chronic and progressive condition like PD, where individuals must continuously adapt to new challenges (Rosengren et al., 2021).

Aligned with the World Health Organization's definition (WHOQOL Group, 1993), participants perceived QoL as a subjective, individual, and multidimensional concept, impacted by physical, mental, emotional, and social factors. This perspective accounts for the experiences and perceptions of the person who grappling with the disease daily (Martinez-Martin, 2017). Considering this definition, Brazilian dance, both in-person and online, can be said to contribute toward improving physical, mental, emotional, and social aspects, and thus enhancing QoL for PwPD. Among the physical benefits of the in-person Brazilian dance classes perceived by the participants are improved physical well-being, reduced stiffness, improved balance, and eased execution of activities of daily living. Improvements in emotional well-being, happiness, enjoyment, and felling of pleasure were also emphasized as essential aspects of the in-person Brazilian dance classes. Also improvements in mood, self-esteem, feeling of empowerment and self-confidence were perceived, which are crucial for QoL in PwPD (García et al., 2019; Palmeri et al., 2019). These results corroborate with previous studies (Carapellotti et al., 2020; Emmanouilidis et al., 2021; Ismail et al., 2021; Zhou et al., 2021; Delabary et al., 2022; Feenstra et al., 2022). However, in addition, the participants reported experiencing other aspects less addressed in the literature, among them feeling of lightness and fluidity in movements, being able to perform daily life activities more easily, and increased agility and energy, all of which contribute to maintain functionality and QoL. Thus, dance can be considered an accessible, engaging, motivating, and enjoyable artistic expression that facilitates PwPD participation (McNeely et al., 2015; Emmanouilidis et al., 2021).

Regarding the online Brazilian dance classes, the participants reported a sense of growing confidence as they overcame technological barriers and engaged in the activities. They emphasized a sense of liveliness, desire and motivation, and energy and disposition. Other positive impacts on emotional and mental well-being were perceived, such as, enhanced memory, and greater strength to cope with the challenges posed by the disease and the pandemic. The literature on the effects of online dance classes in PwPD is relatively recent and has highlighted the benefits and challenges faced during the pandemic (Bek et al., 2021; Delabary et al., 2022). Among the main barriers are difficulty connecting with the internet, a lack of technological knowledge and decreased motivation to participate in dance activities (Bek et al., 2021; Delabary et al., 2022). Despite facing these challenges and missing the physical presence of their peers, the participants perceived several positive aspects, such as: the possibility to stay active by dancing at home, enhanced balance and posture, and improved mood, confidence, and motivation (Bek et al., 2021; Delabary et al., 2022).

While the participants perceived the above physical, mental, and emotional benefits of both in-person and online Brazilian dance classes, the social aspects received greater emphasis. However, the participants perceived greater social benefits with the presence of their peers in the in-person classes. Nevertheless, they stressed the importance of the online dance classes in alleviating feelings of isolation and permitting the interaction with peers during the pandemic. In addition to increased social participation and friendships, the in-person and online Brazilian dance classes fostered a sense of belonging within the group. The participants felt comfortable expressing themselves, engaging in discussions with peers about shared concerns, and receiving support and understanding. This social support was instrumental in reducing self-stigma, enhancing participation, and fostering self-expression. These perceived social benefits align with previous research (Earhart, 2009; Bognar et al., 2017) which demonstrated that dance can improve social participation and change perspectives and attitudes toward Parkinson's.

Overall, the in-person and online Brazilian dance classes offers a nuanced understanding of their impacts on the multifaceted aspects of QoL for PwPD. The in-person Brazilian dance classes were associated with physical improvements, emotional well-being, and increased social benefits, while online classes were noted for overcoming technological barriers, maintaining activity levels, and supporting emotional and mental well-being during the pandemic. Socially, in-person classes provided a stronger sense of camaraderie, while online classes addressed isolation concerns. Both settings fostered a sense of belonging, social support, and improved social participation.

Limitations

This study has some limitations which should be considered. Due the COVID-19 pandemic, the interviews had to be conducted virtually. Consequently, internet failures may have hampered communication. Additionally, in some cases, the presence of a family member or caregiver at home may have impacted the participants' responses. Also, the study faced challenges due to the unprecedented circumstances of the pandemic, making it difficult to conduct comprehensive assessments typically performed in a clinical setting, such as the Unified Parkinson's Disease Rating Scale (UPDRS), due to not conduct in-person interactions with the participants during this period.

Conclusion

The participants perceived various challenges associated with living with Parkinson's, all of which have a negative impact on their QoL. However, a recurring theme in their narratives is the significance of resilience, acceptance, and commitment to treatment in the process of overcoming these challenges and adapting to their new reality. The Dance & Parkinson's project, whether conducted in-person or online (both before and during the COVID-19 pandemic), was shown to improve physical, mental, emotional, and social dimensions, thereby enhancing the participants QoL. The study underscores the potential relevance of Brazilian Dance interventions, including online approaches during the COVID-19 pandemic, as a valuable component in healthcare strategies for populations with chronic conditions.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

This study was approved by the Federal University of Rio Grande do Sul Ethics Committee (CAAE 190 33547920.9.0000.5347). The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Comparison of externally and internally guided dance movement to address mobility, cognition, and psychosocial function in people with Parkinson's disease and freezing of gait: a case series

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Objective: The aim of this study is to explore the impact of internally guided (IG) versus externally guided (EG) adapted tango (AT) dance training (i.e., dancing the IG "Leader" role or the EG "Follower" role), on motor and non-motor functions in individuals with Parkinson's disease and freezing of gait (PD-FOG). The "Leader" role, a proxy for IG movements, conveys direction, timing, and amplitude of steps with tactile cues. The "Follower" role, a proxy for EG movements, detects and responds to the leader's tactile cues.

Case description: Six participants were randomly assigned to the IG ("Leader") or EG ("Follower") roles for 20, 90-min AT lessons over 12 weeks. Participants were assessed for PD-specific and non-PD-specific functions before and twice after the end of the 12-week intervention, at 1-week and 1-month post-intervention.

Results: EG participants improved and/or maintained performance on more outcomes across all domains than IG participants. Five participants improved in PD motor symptoms, dynamic gait, global cognitive function, and the FOG Questionnaire immediately or 1month after intervention. All participants expressed positive attitudes toward the intervention, including improvements in walking, balance, and endurance.

Conclusion: AT training in the follower role may benefit individuals with PD-FOG to a greater extent compared to the leader role.

Impact: This case series study could inform additional research with the goal of enhancing physical therapy or music-based therapy approaches for addressing PD-FOG.

KEYWORDS

Parkinson's disease, freezing of gait, dance, exercise, internal guidance, cueing

Introduction

Parkinson's disease (PD) affects 1% of Americans over 65 (Noyes et al., 2006; Muslimovic et al., 2008; Parkinson's Foundation, n.d.), impairing quality of life (QOL) (Muslimovic et al., 2008). Freezing of gait (FOG) (Nutt et al., 2011), which is a sudden inability to walk, increases the high fall risk in PD (Balash et al., 2005). Fifty-three percent of people with PD diagnosed for 5 years or more experience FOG (Morris M. E. et al., 2001). People with PD-FOG who participate in physical therapy (PT) exhibit improved gait performance and balance and reduced fall rates (Shen et al., 2016). Such interventions use movement strategies that aim at compensatory neural pathways less affected by PD (Freedland et al., 2002; Abraham et al., 2018). Visual and auditory cueing and treadmill training (Rutz and Benninger, 2020) were effective in addressing PD-FOG (Gilat et al., 2021). Several movement strategies use external guidance (EG) through auditory, visual, or tactile cues (Cunnington et al., 1995; Debaere et al., 2003; Tomlinson et al., 2014). EG training has yielded behavioral benefits in people with PD (Rocha et al., 2014), including movement initiation and reaction times in people with PD-FOG (Dibble et al., 2004; Ballanger et al., 2006; Jiang and Norman, 2006). Audio-visual EG training has improved stride length and velocity in people with PD (Mak et al., 2013). Visual EG strategies have improved movement initiation (Jiang and Norman, 2006) and motor imagery in people with PD (Heremans et al., 2012). Auditory EG strategies can result in faster reaction times in people with PD (Ballanger et al., 2006). Lessened FOG in individuals during turns, which was gained from auditory cues, did not last for a substantially long time (Spildooren et al., 2012). It remains unknown which cue types (auditory, visual, somatosensory, and tactile) or combinations of cued guidance are most effective for improving function in people with PD-FOG.

In contrast, internal guidance (IG), which is a self-initiating movement with no external cues, increases step length and speed of movement in people with PD-FOG (Morris M. E. et al., 2001; Morris et al., 2009; Peterson et al., 2016). People with PD improved their gait more when using IG strategies compared to EG strategies (Harrison et al., 2018). IG strategies may require considerable cognitive engagement (Lau et al., 2004) in executive functions (Elsinger et al., 2006).

In adapted tango (AT) (Allen et al., 2017; Silverstein et al., 2020), participants are assigned to "leader" or "followers" roles. AT is a modified form of Argentine tango, which is a highly improvisational dance. Students learn how to lead steps through subtle pressure cues through the arms in the "frame." Students in AT are encouraged to improvise the order of steps in their dances. Partners are trained to coordinate their steps by paying close attention to the tactile cues, and the indicated directions through the body's posture. The leader plans and executes the timing, direction, rotation, and amplitude of the steps, requiring IG of their movements. As such, in this study, we consider the lead role to be mostly but not exclusively an IG strategy. The follower uses EG to make the next move by responding to the leader's tactile and visual guidance and cues about what the next step will be and how it will be executed. Therefore, in this study, we consider the follower role to mostly be using an EG strategy as pertains to what the next dance steps will be. We acknowledge that both of these roles, which involve human movement, require I and EG of movement; however, for the follower to know where to go next because the dance is improvisational, the follower must pay attention to the leader's cues, which provide information about where, how far, and when to step next. The leader, on the other hand, is not being told what the next step will be and therefore must self-determine the next steps and all the parameters about that step. For people with PD, research has shown that AT training incorporates visual, auditory, and, most importantly, tactile cueing to improve motor deficits, disease severity, and cognition in people with PD (Hackney and Earhart, 2010).

Previous studies of AT in PD did not examine the effect of AT on FOG; however, the studies included participants both with and without FOG without taking this difference into consideration (Hackney et al., 2007; Hackney and Earhart, 2009, 2010; McKee and Hackney, 2013). The goal of this exploratory case series is to evaluate the effects of IG-AT training versus EG-AT training on motor, cognitive, and psychosocial functions in six individuals with PD-FOG. As people with PD and FOG exhibit impairments in planning and executing complex goal-directed tasks (Kliegel et al., 2005), we hypothesize that people with PD-FOG will exhibit greater benefits from EG-focused (i.e., follower) AT training, compared to IG-focused (i.e., leader) AT training.

Narrative of the episode of care

The Institutional Review Board at Emory University School of Medicine and the Department of Veterans Affairs Rehabilitation Research & Development committee approved the study. This report adheres to the 2013 CARE case report guidelines (Writing a Case Report, n.d.). Participants provided written informed consent before participation. Participants had idiopathic definite PD (Racette et al., 1999) no other neurological insult, and clinically significant FOG, defined as reporting freezing at least "once a week" on item 3 of the Freezing of Gait Questionnaire (FOGQ): "Do you feel that your feet get glued to the floor while walking, making a turn or when trying to initiate walking (freezing)?" (Giladi et al., 2001; Moore et al., 2007), exclusion criteria were: major psychiatric illness, history of stroke or traumatic brain injury, alcohol abuse and/or use of antipsychotics, severe cardiac disease, and other significant co-morbid diseases. Participants underwent three evaluations while "off" medications. One week before (pre-test) and after finalizing the intervention: directly 1 week after (post-test), and 4–6 weeks after (1-month post). At the post-test, participants completed an exit questionnaire to assess satisfaction and whether they noted improved balance, walking, mood, coordination, strength, and endurance after the intervention (Hackney et al., 2013; McKee and Hackney, 2013). Participants were randomly assigned to the IG (leader) or EG (follower) roles before baseline assessment. Participants received 20, 90-min biweekly AT classes within 12 weeks. Trained, blinded raters administered assessments.

Participants' demographics and clinical characteristics

Participants were Caucasian ($n=4$), Black ($n=1$), and Asian/Caucasian ($n=1$) and were in Hoehn and Yahr stages 2.5–4, had PD 8–18 years, and reported moderate to high fear of falling. All participants were being followed by a movement disorders specialist, reported fully

adhering to their medical regimen, and benefited from anti-parkinsonian medication. All but one participant (EG2) reported the right onset of Parkinson's. Five of the six were considered "fallers," having reported more than two falls in the previous 6 months, with EG3 being a daily faller (182 falls) and IG1 reporting no falls. Participants were all retired, lived independently, and were aged 61–78 years. Participants ranged in exercise habits from daily (IG1) to 1–2 days/week (IG3, EG1, and EG3) to occasional walking only (IG2 and EG2). Four participants used an assistive device, and one (EG2) reported occasional use of a wheelchair. Participants reported moderately good to high QOL on the single-item QOL measure (Table 1).

Outcome measures

PD-specific outcome measures

FOGQ (subjectively evaluates FOG frequency and disturbances in gait, unrelated to falls) (Freezing of Gait Questionnaire, n.d.), the Movement Disorders Society Unified Parkinson Disease Rating Scale revision (MDS-UPDRS) parts I-IV (Movement Disorder Society—Sponsored Unifed Parkinson's Disease Rating Scale Division, 2014), and the Hoehn and Yahr (1967) and Goetz et al. (2004) scale, and the Parkinson Disease Questionnaire-39 (PDQ-39; summary index score and the ADLs subscale score) (Parkinson's Disease Questionnaire-39, 2014) were used to measure the PD-specific outcomes.

Mobility and fall risk outcome measures

The Timed Up and Go [TUG; shorter times indicate a lower risk of falls (Vance et al., 2015)] (Morris S. et al., 2001), Manual Timed Up and Go (TUG-M) (Shumway-Cook et al., 2000), Cognitive Timed Up and Go (TUG-C) (Campbell et al., 2003), Dynamic Gait Index (DGI) (Landers et al., 2008; Huang et al., 2011), Gait Speed (Steffen and Seney, 2008; Fritz and Lusardi, 2009; Abu Samah et al., 2016), Four-Square Step Test (FSST) (Duncan and Earhart, 2013), the Fullerton Advanced Balanced Scale [FAB; measures static and dynamic balance in older active adults and those with PD (Schlenstedt et al., 2015)] (Fullerton Advanced Balance Scale, 2012; Physical Activity Scale for the Elderly (PASE), 2016), and composite physical function (CPF) index (Fullerton Advanced Balance Scale, 2012) were used to measure the mobility and fall risk outcomes.

Psychosocial outcome measures

The Activities-Specific Balance Confidence (ABC) scale (score < 69% indicates risk of recurrent falls. Fear of Falling and QOL are self-rated on a 0–7 Likert scale, with "7" indicating greater fear of falling and better QOL, respectively) (Activities-Specific Balance Confidence Scale, 2013), Short Form-12 Health Survey (SF-12; participant's perspective of health-related QOL with composite scores for physical and mental health. Higher scores on the SF-12 are better) (Short Form 12 Item (version 2) Health Survey, n.d.), and Beck Depression Inventory II (BDI-II; assesses depression, with score > 18 indicating depression in PD) (Beck Depression Inventory, 2012) were used to measure the psychosocial outcomes.

Cognitive outcome measures

The following cognitive outcome measures were administered: Trail Making Test (Reitan, 1955) (for visual attention and task switching), Brooks Spatial Memory (BSM) (Brooks, 1967) (for spatial memory), The Delis-Kaplan Executive Function System (D-KEFS) Tower of London Test (for planning and problem solving), The D-KEFS Color Word Interference Test (CWIT) (Delis et al., 2001) (for executive function over four conditions: color naming, word reading, inhibition and inhibition/switching) (Long et al., 2015), the Montreal Cognitive Assessment (MoCA) (2012), the Reverse Corsi Blocks (Kessels et al., 2008) test (for visuospatial working memory), and the Serial 3's task (Bristow et al., 2016) (for mental tracking capacity and updating). MoCA cut-off scores were as follows: >26/30 indicates screened for normal cognitive function, <26/30 indicates possible mild cognitive impairment, and <18/30 indicates possible PD-dementia.

The Reverse Corsi Blocks (Kessels et al., 2008) test (for visuospatial working memory) and Serial 3's task (Bristow et al., 2016) (for mental tracking capacity and updating).

Baseline assessment

Participants' baseline performance on PD-specific, mobility, and cognitive outcomes is presented in Tables 1, 2.

PD-specific

IG1 and IG3 did not exhibit FOG during MDS-UPDRS-III item 11 (FOG). Other participants demonstrated mild to moderately severe FOG during the MDS-UPDRS assessment. On MDS-UPDRS Parts I and II, all participants reported moderate to severe difficulty. On MDS-UPDRS Part III, all participants had moderate severity. All participants—besides IG2—reported medication-related motor fluctuations per the MDS-UPDRS IV. On PDQ-39, all participants—except IG2, who scored below the mean—had normative scores for health-related QOL (Parkinson's Disease Questionnaire-39, 2014).

Mobility and fall risk

Scores on DGI, which were less than 19/24, and FAB, which were less than 25/40, indicated elevated fall risk in all participants, except EG3. A score of <19/24 on the DGI is predictive of falls, while scores of 22 or above indicate safe ambulators (Landers et al., 2008; Huang et al., 2011). Lower FAB scores indicate difficulty with higher level static and dynamic balance tasks. A score of <25/40 is predictive of increased fall risk (Schlenstedt et al., 2015).

The FSST results for all participants—except EG1 and EG3—indicated elevated fall risk because a score of more than 9.7 s to complete the FSST is predictive of increased fall risk. Participants' retropulsion scores on the MDS-UPDRS-III and their Hoehn and Yahr ratings indicate postural instability because a score of 2.5 or greater on the Hoehn and Yahr, which all participants had, is indicative of the cardinal sign of postural instability (determined by the retropulsion test, in which patients took three or more steps to recover, or were caught by the examiner). On the CPF, only EG1 and IG3 were considered "high functioning" in performing ADLs without help; other participants were not fully independent with all tasks. EG2 was a "low functioning" participant and the most at risk for declining physical independence. On the CPF, a score of ≥14 indicates moderate functioning, and a score of <14 indicates low functioning.

Psychosocial

Participants IG1, IG3, EG2, and EG3 had low balance confidence, per ABC scores. On BDI-II, IG1, EG2, and EG3 scores indicated

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TABLE 1 Participants' demographics and medical history.

	IG1	IG2	IG3	EG1	EG2	EG3
Group	Internally guided training	Internally guided training	Internally guided training	Externally guided training	Externally guided training	Externally guided training
Age (y)	66	71	69	68	78	61
Sex	Male	Female	Male	Male	Female	Female
Race	Caucasian	Black	Caucasian	Caucasian	Caucasian	Asian/Caucasian
Time since diagnosis (y)	8	12	16	16	14	18
Hoehn & Yahr stage	2.5	3	2.5	3	4	3
Disease onset	Right	Right	Right	Right	Left	Right
No. of falls in 6 months before the study	0	3	3	6	7	182
Observed FOG during MDS-UPDRS assessment	No	Yes	No	Yes	Yes	Yes
Freezing of gait questionnaire (/24 total score) (item 3)	12 (3)-(about once a day)	6 (2)-(about once a week)	14 (2)-(about once a week)	12 (3)-(about once a day)	4 (4)-(whenever walking)	20 (3)-(about once a day)
Composite physical function (CPF) index (/24)	Moderate functioning (20)	Moderate functioning (16)	High functioning (24)	High functioning (24)	Low functioning (7)	Moderate functioning (18)
Fear of falling (/7)^	7	3	4	4	5	7
Quality of life (/7)^	4 (moderate)	5 (moderately good)	5 (moderately good)	3 (low)	4 (moderate)	6 (high)
Beck depression inventory II	20	9	12	12	23	23
Physical activity scale for the elderly (PASE)	62.01	130	190.7	145.1	75.53	53.6
ABC scale (/100)	66.9	86.3	68.1	91.3	68.1	50.6
Medications	PD specific: Carbidopa-Levodopa 25 mg-100 mg tab; Non-PD Specific: Bupropion HCL XL 150 mg, Myrbetriq ER 50 mg, Omeprazole DR 40 mg, Cialis 5 mg	PD specific: Carbidopa-Levodopa 25 mg-250 mg, Selegiline 5 mg; Non-PD Specific: Seroquel 25 mg, Carvedilol 12.5 mg, Nexium, Levothyroxine 0.125 mg, Magnesium citrate, Meclizine 25 mg, Pravastatin 20 mg, Travatan Z, Ubiquinone 100 mg, Diovan 160 mg	PD specific: Carbidopa-Levodopa 25 mg-100 mg, Mirapex 0.5 mg, Amantadine 100 mg, Comtan 100 mg; Non-PD Specific: Trazadone 100 mg, Coumadin/Warfarin 2 mg, Simvastatin 40 mg	PD specific: Carbidopa-Levodopa 25 mg-100 mg; Non-PD Specific: Bupropion HCL XL 150 mg, Omeprazole DR 4omg, Myrbetriq ER 50 mg, Cialis 5 mg	PD specific: Carbidopa-Levodopa 25 mg-200 mg, Amantadine 100 mg; Non-PD Specific: Lexapro 10 mg, Lortab 5/500 mg, Atorvastatin 20 mg, Cyanocobalamin 100mcg/mL, Colace 100 mg, Nexium 40 mg, Lunesta 2 mg, Proctocort 30 mg, Lidocaine 5% topical ointment, Metoprolol tartrate 25 mg, Conjugated estrogens 0.625 mg/g, Premarin 0.45 mg	PD specific: Carbidopa-Levodopa, Mirapex, Entacapone, Amantadine; Non-PD Specific: Mirtazapine

*Freezing of gait questionnaire (FOGQ) Item 3 (/4): "Do you feel that your feet get glued to the floor while walking, making a turn or when trying to initiate walking (freezing)?"
^Fear of falling and quality of life are self-rated on a 7-point Likert scale, from 0 to 7, with higher scores indicating more fear of falling or quality of life.
MDS-UPDRS: movement disorders society unified parkinson disease rating scale.

significant depression. All participants fell under the mean score of 50 on the physical and mental composite score for the SF-12, indicating worse self-reported physical and mental health. On PASE, IG1 and EG3 reported lower levels of physical activity (Washburn et al., 1993).

Cognitive

On MoCA, at baseline, all participants (range MOCA: 21–25) but EG3 (MOCA score: 28) exhibited possible mild cognitive impairment (score < 26/30) (Chou et al., 2010). On Corsi blocks, IG1, IG2, EG1, and EG2 scored significantly lower than their age group's normative

TABLE 2 Outcome performance[a].

	EG1			EG2			IG1			IG2			IG3			EG3		
	Pre	Post	1MTH post	Pre	Post	1MTH post	Pre	Post	1MTH post	Pre	Post	1MTH post	Pre	Post	1MTH post	Pre	Post	1MTH post
Movement disorders society unified parkinson's disease rating scale																		
I. Non-motor experiences of daily living (/52)	22	20	16	16	7	8	29	21	16	14	18	16	13	11	7	14	13	14
II. Motor experiences of daily living (/52)	19	18	15	32	18	26	31	24	28	13	11	13	14	18	19	17	19	17
III. Motor examination (/132)	48	39	34	57	57	55	56	47	44	40	32	31	31	31	29	46	49	51
IV. Motor complications (/24)	6	4	6	1	3	0	6	1	9	0	3	6	10	8	12	9	9	6
MDS-UPDRS total (/260)	95	81	71	106	85	89	122	93	97	67	64	66	68	68	67	86	90	88
Freezing of gait questionnaire (/24)	12	13	12	17	22	18	12	13	10	6	6	6	14	14	13	20	16	17
Gait speed fast	1.45	1.51	1.49	0.55	0.30	0.69	1.52	1.61	1.40	1.12	1.13	1.27	1.22	1.11	1.14	1.53	1.65	1.69
Gait forward	1.11	0.87	1.08	0.38	0.21	0.53	0.86	1.00	0.76	0.76	1.14	0.98	0.89	0.73	1.05	1.09	1.18	1.07
Backward	0.74	0.77	0.79	0.13	0.06	0.09	0.57	0.46	0.56	0.29	0.26	0.41	0.79	0.64	0.74	0.40	0.42	0.56
Timed up and go (TUG) (s)	7.7	9.4	8.5	50.0	95.5	22.4	8.8	12.3	9.2	11.4	11.71	11.0	10.4	9.9	10.3	9.0	9.7	8.7
TUG-cognitive (s)	9.3	10.8	10.4	167.1	206.9	72.5	17.7	28.4	16.1	16.6	14.6	15.0	11.8	20.1	14.3	14.3	20.6	14.8
TUG-manual (s)	10.0	14.6	13.4	133.1	–[c]	91.9	17.4	12.8	17.4	14.7	12.8	13.3	12.4	14.0	17.4	11.6	13.6	12.7
Dynamic gait index (/24)	16.0	18.0	22.0	2.0	11.0	16.0	19.0	21.0	21.0	18.0	20.0	21.0	23.0	19.0	19.0	18.0	18.0	19.0
Fullerton advanced balance (/40)	19.0	29.0	31.0	13.0	6.0	16.0	24.0	25.0	19.0	23.0	22.0	20.0	35.0	35.0	36.0	20.0	26.0	23.0

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TABLE 2 (Continued)

	EG1			EG2			IG1			IG2			IG3			EG3		
	Pre	Post	1MTH post	Pre	Post	1MTH post	Pre	Post	1MTH post	Pre	Post	1MTH post	Pre	Post	1MTH post	Pre	Post	1MTH post
Four-square step test (s)[b]	8.8	9.0	8.2	24.2	31.3	–[c]	14.2	13.9	13.9	15.6	14.5	14.2	13.3	10.3	9.8	9.0	10.2	14.2
Composite physical function (/24)	24.0	24.0	23.0	7.0	7.0	9.0	20.0	21.0	16.0	16.0	14.0	16.0	24.0	18.0	22.0	18.0	17.0	17.0
Parkinson's disease questionnaire (PDQ-39)																		
Summary index	33.6	13.7	21.6	60.4	26.3	27.8	47.8	49.0	38.3	10.5	19.3	34.3	30.3	25.9	26.4	37.4	55.6	35.9
PDQ-39 ADL	25.0	20.8	12.5	75.0	33.3	16.7	50.0	41.7	41.7	4.2	4.2	4.2	37.5	29.2	25.0	37.5	66.7	33.3
PDQ-39 stigma	31.3	0.0	6.3	75.0	0.0	0.0	25.0	0.0	12.5	12.5	6.3	43.8	12.5	6.3	0.0	0.0	37.5	18.8
PDQ39 mobility	15.0	7.5	0.0	75.0	85.0	47.5	42.5	52.5	25.0	17.5	12.5	35.0	55.0	30.0	30.0	47.5	95.0	25.0
PDQ-39 emotional well-being	37.5	12.5	41.7	75.0	33.3	62.5	37.5	41.7	20.8	0.0	0.0	0.0	20.8	4.2	20.8	16.7	41.7	25.0
PDQ-39 social support	41.7	8.3	25.0	91.7	16.7	41.7	16.7	50.0	16.7	0.0	0.0	50.0	25.0	8.3	37.5	0.0	8.3	8.3
PDQ-39 cognition	43.8	18.8	37.5	0.0	0.0	12.5	68.8	56.3	56.3	0.0	31.3	50.0	25.0	37.5	31.3	81.3	62.5	68.8
PDQ-39 bodily discomfort	33.3	41.7	25.0	58.3	41.7	25.0	91.7	75.0	66.7	25.0	50.0	41.7	41.7	58.3	41.7	41.7	33.3	58.3
PDQ-39 communication	41.7	8.3	25.0	33.3	0.0	16.7	50.0	75.0	66.7	25.0	50.0	50.0	25.0	33.3	25.0	75.0	100.0	50.0
Beck depression inventory	12	17	15	23	8	13	20	11	16	9	10	0	12	12	9	23	20	18
SF12 physical composite score	47.3	49.9	55.0	31.2	37.6	51.7	37.9	40.9	36.8	47.1	36.7	41.6	28.7	39.6	46.6	47.8	46.4	42.0
SF 12 mental composite score	40.9	44.0	41.9	35.6	44.4	42.7	31.6	34.2	42.9	50.2	46.7	44.2	51.2	48.5	39.3	31.5	26.2	27.3
Activities-specific balance scale (%)	91.3	87.5	83.8	68.1	75.6	70.6	66.9	76.3	78.8	86.3	80.6	89.4	68.1	63.8	66.3	50.6	47.5	21.9

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TABLE 2 (Continued)

	EG1			EG2			IG1			IG2			IG3			EG3		
	Pre	Post	1MTH post	Pre	Post	1MTH post	Pre	Post	1MTH post	Pre	Post	1MTH post	Pre	Post	1MTH post	Pre	Post	1MTH post
Montreal cognitive Assessment (/30)	25	28	28	21	26	22	19	24	21	24	22	26	24	25	26	28	29	28
Tower of london achievement score	15	18	15	11	9	14	4	0	2	8	6	10	10	13	16	17	19	20
Trails making test-A	25.1	23.1	27.1	59.2	45.9	67.6	88.3	142.8	136.3	65.8	35.3	26.4	23.7	31.5	27.9	28.4	25.4	20.8
Trails making test-B	70.4	63.8	79.0	300[d]	182.8	185.4	300[d]	300[d]	300[d]	159.2	190.6	147.7	140.1	96.1	150.4	44.3	47.0	74.6
Trails difference (B-A)*	45.3	40.7	51.9	N/A	136.9	117.8	N/A	N/A	N/A	93.4	155.3	121.3	116.4	64.5	122.5	16.0	21.6	53.9
CWIT-d inhibition completion time (s)	9	7	11	5	9	2	2	1	–[c]	2	7	7	4	2	6	8	11	11
CWIT-d Inhibition/ switching Completion time (s)	11	13	13	9	10	9	2	–[c]	–[c]	6	5	7	8	1	8	10	13	13
CWIT-d inhibition total corrected and uncorrected errors	12	8	12	9	13	10	1	1	–[c]	11	11	13	8	9	10	1	8	4
CWIT-d inhibition/ switching total corrected and uncorrected errors	4	12	11	6	9	4	1	–[c]	–[c]	7	6	12	8	5	7	9	9	10

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TABLE 2 (Continued)

	EG1			EG2			IG1			IG2			IG3			EG3		
	Pre	Post	1MTH post	Pre	Post	1MTH post	Pre	Post	1MTH post	Pre	Post	1MTH post	Pre	Post	1MTH post	Pre	Post	1MTH post
Serial 3s (% correct)	100.0	97.8	90.5	100.0	94.1	100.0	75.0	68.4	85.0	84.2	100.0	100.0	100.0	100.0	100.0	93.8	96.0	85.7
Corsi blocks product (span * number correct trials)	20	42	20	24	30	20	9	6	16	20	30	30	42	20	20	40	40	48
Brooks spatial memory (% correct)	60	72	–[c]	54	58	70	36	24	20	64	44	52	64	68	86	62	58	58

[a]Participants are sorted from left to right according to progressively worse performance. Green cells represent improved or maintained performance compared to pre-test. Red cells indicate declined (i.e., more than 5%) performance relative to pre-test.
[b]Scores scaled to normative data. CWIT = color-word interference test.
[c]Participant was unable to complete the test.
[d]Participant exceeded the time allowed to complete the test and did not complete the test.

score, whereas IG3 and EG3 scored higher (McKee and Hackney, 2013; Abraham et al., 2018).

Therapeutic interventions

Participants attended 20, 90-min AT classes at the Atlanta VA Medical Center over 12 weeks and were encouraged to attend two classes per week. All classes included review/practice, warm-up, rhythmic entrainment/partnering enhancement, new steps, combining previous steps, and cool down (Hackney and McKee, 2014) (Table 3). People with PD always danced with individuals without PD (i.e., caregivers or student volunteers).

Follow-up and outcomes

All participants completed 20 lessons within 12 weeks. IG2 and EG3 experienced near-falls during AT sessions, which were prevented by AT partners. EG3 experienced a non-injurious fall during a FOG episode while turning, resulting in a loss of balance and an eventual fall to the ground. She was immediately attended to by a trained clinician, and she could continue therapy.

After intervention, EG-AT improved or maintained performance more consistently on 23 outcome variables, while IG-AT improved/maintained performance more consistently on 12 outcomes, and both IG-AT and EG-AT improved/maintained performance equally on 6 outcomes (meaning that there were more timepoints with improvement or maintenance across all three participants in a group compared to that of the other group) (Table 2). Five participants improved global cognition and reported less detriment to QOL. All participants, except EG2, improved FOGQ scores, either at post-test or 1-month post-test. EG3, who had severe freezing, improved both at the post-test and 1-month post-test. Participants improved in outcome measures across all domains, regardless of whether they were assigned to the EG-AT or IG-AT roles (Table 2). All participants besides IG3 improved dynamic balance, per the DGI. All IG-AT participants and EG1 improved on FSST. DGI scores were maintained or improved at the post-test and further improved at the 1-month post-test for all participants except IG3. MoCA and MDS-UPDRS total scores showed consistent responses over time, regardless of EG-AT or IG-AT allocation. Figure 1 shows performance on FOGQ, MoCA, DGI, forward gait, FSST, and the FAB.

Patients' perspective

Participants' impressions of AT as per the exit questionnaire were overall positive; participants strongly agreed (i.e., rating of "1") that they enjoyed the intervention and would continue participating if possible. Four out of six participants expressed that the intervention encouraged them to be more physically active and helped them improve their balance, walking, and endurance. All participants, except EG1, agreed that the intervention encouraged them to be more mentally active. Participants appreciated the social aspects of AT, including interaction with other participants, class instructors, and volunteers.

TABLE 3 Adapted tango class sections and implications for participants' roles.

Class section/time	Implications for IG and EG participants
Greeting and review: practice/10 min	Both groups practice steps from the previous classes.
	IG participants create movements step sequences and initiate them during the warm-up, allowing them to remember previously learned moves and be more creative for their partners. After 10 lessons, they will have a larger bank of moves to pull from, increasing the difficulty of selecting moves to lead their partner through.
	EG participants follow tactile cues via tactile cues on their forearms and hands from their partner and do not determine timing, rotation, direction, or amplitude of steps.
Warm-up/20 min	Instructor leads exercises to emphasize range of motion in joints from head to toe, rotational movement of the trunk, contra-body motion, and focus on breathing and postural alignment.
Rhythmic entrainment/partnering enhancement/20 min	Enhances the participant's feel of the musical beat.
	IG participants are instructed on how to effectively communicate via tactile forces and pressure movement goals (e.g., amplitude, timing, and rotation) to the EG participants.
	EG participants increase their ability to respond to the tactile cues from the IG participants.
New step/15 min	A new step is taught in every class.
	IG participants lead EG partners through the new step, using tactile cues via force and pressure through the hands and arms of the dance frame position.
	EG participants respond to the tactile cues from the IG participant.
Combining previous steps/20 min	Participants are given three steps to practice, allowing for increased repetition and creativity in combining the steps.
	IG participants are responsible for deciding how to combine the three given practice steps (in a self-determined order, and number of iterations per step), allowing for increased repetition and creativity in combining the steps.
	EG participants follow the IG participants through the three practice steps for the session, responding only to tactile cues. Ideally, after 10 lessons the EG participant has an enhanced ability to strictly follow cues from the IG participant, refraining from anticipating/initiating movements without proper cueing.
Closing/cool down/5 min	Gather in a circle to finish with breathing exercises and stretching techniques, bringing the heart rate back down. Discuss class accomplishments and build a community learning environment.

Discussion

Like AT, PT for people with PD incorporates visual or auditory cueing, which decreases the length and severity of FOG episodes. AT may be a unique program that positively impacts individuals with PD with FOG while providing PD-symptom relief. This study demonstrates that AT is appropriate and safe for those with FOG and that they could dance the leader or follower role. These results suggest that AT could reduce FOG. AT programs for people with PD-FOG could be applied and further adapted to meet the physical and non-physical needs of people with PD-FOG and engage partners and caregivers. Although result maintenance varied greatly at the 1-month post-test, positive changes from pre-test to post-test suggest that AT could be clinically relevant for treating individuals with PD-FOG, with marginal findings suggesting greater benefit for those who complete EG-AT training. Because PD is a progressive neurodegenerative disorder and FOG is a harbinger of worse outcomes, we interpret these results while considering an expected decline in performance over time, even with the best of pharmacological treatments. As such, maintaining scores post-intervention may be a positive effect of AT.

The improvements noted in the MDS-UPDRS parts I–IV and total score for several participants (regardless of group allocation) exceeded the minimal clinically important difference (MCID), indicating that these participants may have experienced considerable functional gains after the program (Mishra et al., 2024). Several participants were able to exceed the cutoff of 18 points on the DGI for safe ambulation, while three participants exceeded the threshold for fall risk on the FAB. Four out of six participants met or exceeded the MCID for the PDQ-39SI, suggesting improved health-related QOL in this highly vulnerable group of individuals with PD (Horváth et al., 2017). While these results are encouraging, the variability apparent in these scores underlines the struggles both clinicians and patients must face while treating FOG.

This case series provides an initial investigation of PD-FOG individuals' motor, psychosocial, and cognitive responses to AT and for managing their safety, functional independence, and wellbeing. Future studies into the effect of AT on PD-FOG should include larger samples, longer follow-ups, and fine-tuning of AT by emphasizing more individualized FOG-related elements.

Limitations

Participants did not dance in structured adapted tango classes in the month following treatment cessation. Participants ceased their structured dance classes but otherwise continued their daily activities. We examined participants after a washout largely to observe any maintenance of gains. At 1-month post-training, we observed maintenance, improvement, and declines with respect to baseline. In some cases, there were declines at the post-test that were followed by improvement at the 1-month post-test. Whether these improvements can be attributed to the dance program is not entirely clear. People with PD-FOG regularly experience fluctuations in their medication regimen and in their functional status that are not entirely explained by pharmacology, neuropathophysiology, or patient emotional status. Because of day-to-day fluctuations, possibly the participant had a

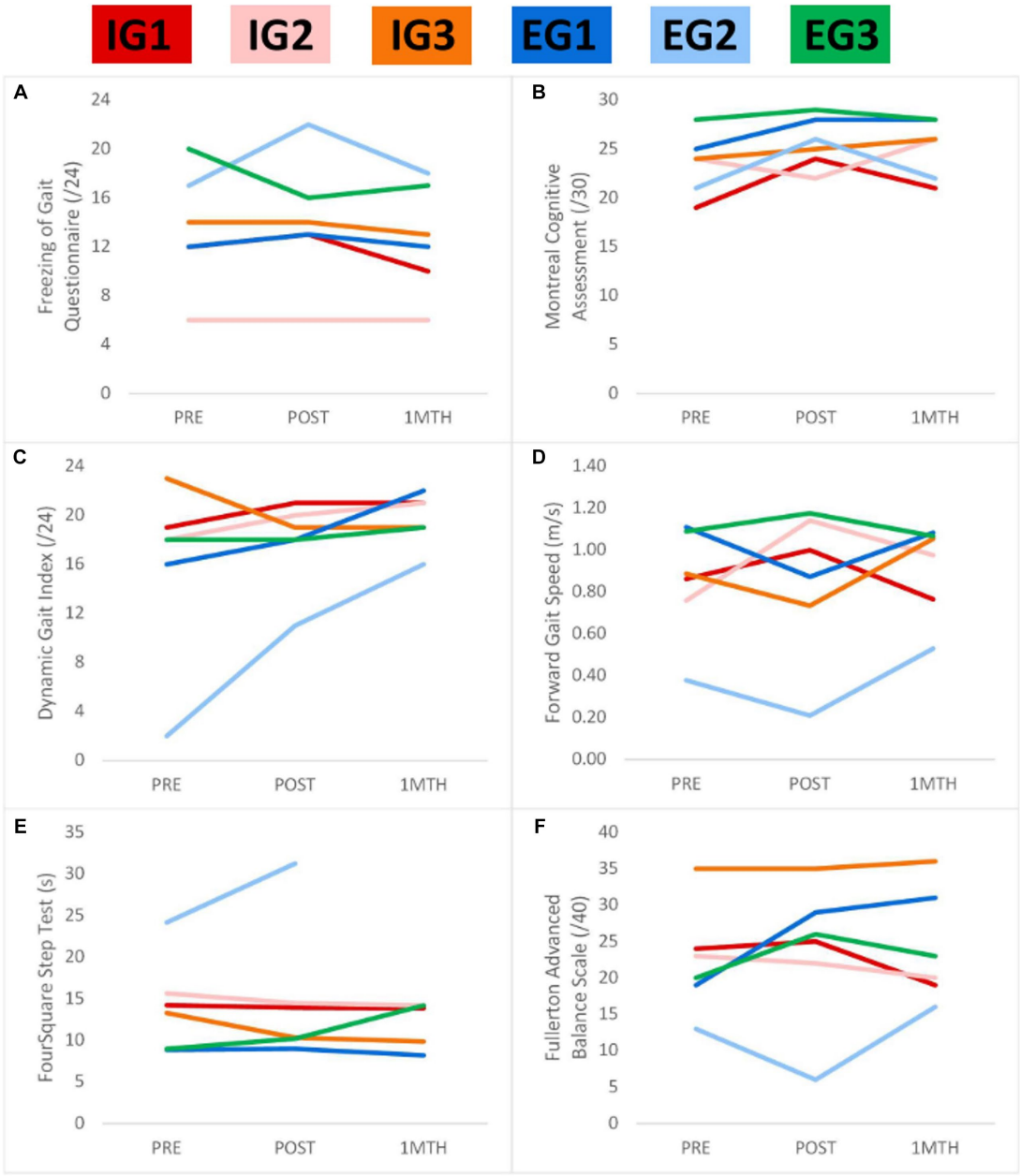

FIGURE 1
Performance over the trial on the freezing of gait questionnaire **(A)**, montreal cognitive assessment **(B)**, dynamic gait index **(C)**, forward gait speed **(D)**, four-square step test **(E)**, and fullerton advanced balance scale CEL legend at the top shows the colors of participants. Self-reported freezing of gait **(A)** was maintained for most participants. Most participants improved in global cognition **(B)**, gait **(C,D)**, balance **(C,F)**, and mobility/motor cognition **(E)**. One-month post-test data were not available for EG2 for FSST. *Lower scores for FSST and FOGQ indicate better outcomes.

low-performance day that was followed by a high functional status day at the 1-month post-test. Alternatively, it is possible that some improvements emerge some weeks after the training has ceased because participants had time to process and practice what they learned during their training program, resulting in enhanced performance at 1-month post-test. Further study is required to understand the variance in performance over time in people with PD-FOG. The case series model has low internal validity due to its inability to report a causal effect and its vulnerability to selection bias. Isolating IG and EG training presents difficulties due to some overlap in training between the two strategies. For example, EG-AT participants would sometimes anticipate instead of responding to their leader and initiate self-movement. IG-AT participants may have experienced EG cueing with music during the AT sessions. These overlaps should be further addressed in future studies.

Data availability statement

The original contributions presented in the study are included in the article/Supplementary material, further inquiries can be directed to the corresponding author.

Ethics statement

The studies involving humans were approved by the Institutional Review Board at Emory University School of Medicine. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study. Written informed consent was obtained from the individual(s) for the publication of any potentially identifiable images or data included in this article.

Author contributions

AA: Conceptualization, Visualization, Formal Analysis, Writing – review & editing, Writing – original draft. AH: Project administration, Data curation, Writing – original draft, Writing – review & editing. AB: Project administration, Data curation, Writing – original draft, Writing – review & editing. SP: Formal Analysis, Visualization, Writing – original draft, Writing – review & editing. SW: Investigation, Writing – original draft, Writing – review & editing. KS: Writing – original draft. MC: Writing – original draft, Project administration. JP: Writing – original draft. AB: Writing – original draft. MT: Writing – original draft. CA: Writing – original draft. TP: Writing – review & editing. MH: Funding acquisition, Investigation, Methodology, Data curation, Conceptualization. Writing – original draft, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fnagi.2024.1372894/full#supplementary-material

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The existential realities of dancing

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Can we again learn about ourselves and our surrounding world through dance as we age, thereby promoting our own health? This article documents facts of life showing that "older adults" do not have to learn to be cognitive of their movement, affective dispositions, or surrounding world; they have been experientially cognitive of all by way of tactility, kinesthesia, and affectivity from the beginning. Present-day cognitive neuroscience, concentrating and theorizing as it does on the brain's neuroplasticity, is however deficient in recognizing these experiential realities. Research studies on the brain and behavior, in contrast, demonstrate that coordination dynamics are the defining feature of both neurological and kinesthetic coordination dynamics. These dynamics are central to corporeal concepts, to the recognition of if–then relationships, and to thinking in movement. In effect, the brain is part of a whole-body nervous system. The study proceeds to show that the qualitative dynamics of movement that subtend coordination dynamics are basic to not only everyday movement but also to dancing—to experiencing movement kinesthetically and to being a mindful body. When Merce Cunningham writes that dance gives you that "single fleeting moment when you feel alive" and is not for "unsteady souls" and English writer D. H. Lawrence writes that "[w]e ought to dance with rapture that we are alive, and in the flesh, and part of the living incarnate cosmos," their words are incentives to those who are aging to awaken tactilely, kinesthetically, and affectively to the existential realities of dance.

KEYWORDS

coordination dynamics, qualitative dynamics, wellbeing, mindful bodies, brain

Can we again learn about ourselves and our surrounding world through movement as we age, thereby promoting our own health? In other words, can we learn by moving and being attuned tactilely and kinesthetically to our movement as we grow down just as we learned by moving and being so attuned when growing up? To answer this question and specify the relation between health in aging and not just moving but also dancing, several clarifications are necessary and warrant attention.

Clarifications: facts of life and their relevance

The idea that dancing and "embodied cognition" are separate human abilities properly and commonly studied in separate discipline research programs that must thus be shown to be conjoined does not accord with experience. Dancing awakens experienced existential realities not of *having a body* but of *being a body*. It awakens a tactilely, kinesthetically, and affectively attuned body experiencing its own movement; thus, a mindful body directly and immediately feels the qualitative dynamics of its movement, whether when reaching for a glass, running to greet a friend, throwing the covers off the bed, trimming a hedge, or dancing. Kinesthesia and tactility are ever-present sensory faculties of living and lived bodies. They do not turn on and off like a switch. Thus, to begin, realizing that the duality of dancing and cognition is imposed is important; like the body and the brain and the mind and the body, the duality of

dancing and cognition, even dancing and "embodied cognition," is not a rock-bottom, experientially natural state of being. On the contrary, it is a fabricated state of being, an inaccurate description of living and lived bodies— both human and non-human.

Animate forms of life do not come into the world as mere moving bodies that must *learn* to be cognitive of their own movement and the immediate world around them that they, in fact, feel directly by always being tactilely and kinesthetically connected with it in both movement and stillness from the start. Barring pathological conditions, human infants are indeed already naturally attuned to cognitions, cognitions not in need of "embodiment" for they are already bodily formed and tethered, both tactilely and kinesthetically, and, in fact, affectively, for example, when stretching, kicking, crying, and feeling tears rolling down cheeks, or lying quietly in a crib.

The preceding developmental facts of life highlight the fact that the belief, idea, or claim that dancing and cognition are basically separate human abilities does not accord with experience. In effect, just as infants do not come into the world as mere moving bodies that must learn to be cognitive, so "the elderly" do not enter the world of dance as mere moving bodies that must learn to be cognitive of their movement or affective disposition to move or be cognitive of the immediate world about them that which they have been directly connected to tactilely, kinesthetically, and affectively from the start. Older adults are indeed not a new hominid species or a diminished form of the species *Homo sapiens sapiens*. However oblivious, non-attentive, and even disdainful they might have been or even now are of their bodies, older adults, like infants, are nevertheless naturally attuned to cognitions that do not need validation or sanctification as a "brain event," for cognitions are naturally experientially formed and tethered in tactilely, kinesthetically, and affectively felt and perceiving bodies in both their movement and stillness. In fact, the brain of any animate form of life is part of *a whole-body nervous system* and thus is an integral part of an individual's anatomical, physiological, and existential being and, furthermore, an individual being the individual that it is.

One might credibly judge that some of "the elderly" have lost their awareness of themselves as *being a body* and thus lost a tactile-kinesthetic awareness and an attentiveness to the flow of their movement as they move, with their bodily awareness now tethered simply to their being unable to move in their earlier customary and even routine ways and not being able to do certain things. In effect, the cognitions of these individuals are limited regarding movement, being commonly linked in a tunneled way with an object of some kind, be it a key, a door, a fly, or a person (as well as a diverse range of other animate forms of life), and accomplishing something with it.

Present-day cognitive science commonly interprets cognitions as brain events. Of considerable interest in this context are the comments of the prime subject of an extensive research program titled the "Interesting Brains Project." The project focuses on differences in the structure of human brains and is written about at length in an article in *Science News* by Meghan Rosen, a staff writer of the journal. Rosen (2023) notes, for example, that some human brains "have holes in their frontal or temporal lobes; others are missing parts of their cerebellum.... Still other participants have brain matter that's squished up against the sides of their skull; scans show voids that appear to have ballooned from the brain's center" (pp. 19–20). In particular, Rosen examines what Elyse G., a prime subject of the project, points out in the opening section of an article on the Project by cognitive neuroscientist Evelina Fedorenko, which might be considered either a cautionary note, a wake-up call, or both: "Please do not call my brain abnormal, that creeps me out.... My brain is atypical. If not for accidently finding these differences, no one would pick me out of a crowd as likely to have these, or any other differences that make me unique." Rosen later emphasizes the fact that "Elyse hopes the message [her message] comes through for doctors and research scientists, immediately quoting directly from Elyse G.'s message: "I want them [doctors and research scientists"] to understand that this is a person they're reading a paper about, not a disembodied brain in a jar" (ibid., p. 21). Indeed, Elyse's brain is not a 'brain in a vat', as in thought experiments focused on "the brain" by earlier scientists and philosophers. Her brain is, like her liver and kidneys, her arms and legs, a living part of the whole living person that she is and, as pointed out earlier, is *part of a whole-body nervous system*.

Furthermore, in this context, research studies on *coordination dynamics* are critically important. In particular, J. A. Scott Kelso, founder and director of the Center for Complex Systems and Brain Sciences, has descriptively and informatively written in ever-enlightening ways and perspectives about how, with respect to the complexity of the brain, "[a]t each level of complexity, novel properties appear whose behavior cannot be predicted from knowledge of component processes alone. To reduce a person's behavior to a set of molecular configurations is, as English neurobiologist Steven Rose once said, to mistake the singer for the song" (1995, pp. 227–228). The discovery of Kelso spells out the basic dynamic character of the brain's coordination dynamics in an experience, namely, his reading and then following a directive printed on the Yellow Pages phone directory: "Let Your Fingers Do the Walking." In wondering how to demonstrate the spontaneously self-organizing dynamic patterning, he let his fingers do the walking and discovered *spontaneous phase transitions*. He writes:

> It is the winter of 1980 and I'm sitting at my desk in my solitary cubicle late at night. Suddenly from the dark recesses of the mind an image from an ad for the Yellow Pages crops up: 'Let your fingers do the walking'. To my amazement I was able to create a 'quadruped' composed of the index and middle fingers of each hand. By alternating the fingers of my hands and synchronizing the middle and index fingers *between* my hands, I was able to generate a 'gait' that shifted involuntarily to another 'gait' when the overall motion was speeded up.... On hindsight, the emergence of this idea was itself a kind of phase transition. (Kelso, 1995, p. 46)

As commented and elaborated elsewhere, "The *idea* of letting his fingers do the walking was a spontaneous breakthrough into a new mode of thinking about spontaneously self-organized movement. It was, in other words, an *ideational* phase transition that aptly and finely exemplifies *thinking in movement*" (Sheets-Johnstone, 1981, 1999/2011, italics added; see also Sheets-Johnstone, 2010a, 2014c). Cognitive achievements that result from thinking in movement are commonly affectively charged, as in the phrase "To my amazement." Cognition and affectivity involve us

in the world, meaning that they animate us, are foundational to our being the animate forms we are, and lead us to explore, doubt, fear, come to know, wonder, delight in, and so on, such as when, for instance, we "let our fingers do the walking." Kelso (1995) precisely recognizes the centrality of animation—of movement—when he writes,

> It is important to keep in mind... that the brain did not evolve merely to register representations of the world; rather, it evolved for adaptive action and behavior.

> Musculoskeletal structures coevolved with appropriate brain structures so that the entire unit functions together in an adaptive fashion.... [I]t is the entire system of muscles, joints, and proprioceptive and kinesthetic functions plus appropriate parts of the brain that evolves and functions together in a unitary way. (p. 268)

Kelso's specification of how *metastability* undergirds coordination dynamics is informative from several perspectives. Kelso (2022) begins by defining and then succinctly describing metastability: "*metastability* (from meta meaning beyond)... is a key dynamical mechanism for understanding how interacting components engage and disengage fluidly and synergistically over time (Kelso, 1995)." (Kelso, 2022, p. 9). He then explains in fine, edifying detail (ibid.):

> Metastable phase attraction between neural ensembles over multiple frequency bands has been proposed to explain how brains flexibly enter and exit coherent spatiotemporal patterns of neural activity (e.g., Bressler and Kelso, 2001; Aguilera et al., 2016; 2016; Fingelkurts and Fingelkurts, 2004; Schwappach et al., 2015). Fluid thinking, from the perspective of metastable coordination dynamics, is when brain rhythms are neither completely synchronized nor desynchronized. Instead of phase synchronized states that must be destabilized if switching is to occur, metastability consists of a subtle dwell and escape dynamic in which thinking is never quite stable and merely expresses the joint *tendency* for neural areas to synchronize together and to oscillate independently. Metastable coordination dynamics rationalizes James (1980) beautiful metaphor of the stream of consciousness as the flight of a bird whose life journey consists of "perchings" (phase gathering, integrative tendencies) and "flights" (phase scattering, segregative tendencies). Both tendencies appear to be crucial: the former to summon and create thoughts; the latter to release brain regions to participate in other acts of being, knowing, and doing (Kelso, 2008).

In sum, what many present-day neuroscience researchers invoke as the "neuroplasticity" of the brain[1] is a matter of metastable coordination dynamics that lucidly specify and describe the shifting nature of neuronal connections and the cognitive gifts of their flexibility. In complementary ways, previous research of earlier scientists testifies to the existential import of a brain's metastable coordination dynamics and its everyday and new cognitive gifts. Based on his investigations and studies, physiological psychologist Sperry (1939, p. 295) concluded not only that the brain is an organ of and for coordinated movement but that the function of consciousness or subjective experience is also "*coordinated movement*" (Sperry, 1952, p. 309). Sperry's conclusions document the preeminence of movement in animate lives and the ability to think in movement. Moreover, neuroscientist and neurophysiologist Marc Jeannerod's conclusion regarding the sensory modality of kinesthesia testifies similarly to the preeminence of movement in animate lives and the ability to think in movement. After a lengthy examination of "conscious knowledge about one's actions" and conducting research that addressed the question of such knowledge and included experimental studies focused on pathologically afflicted individuals, Jeannerod (2006, p. 56) concluded: "There are no reliable methods for suppressing kinesthetic information arising during the execution of a movement."

The import of moving to wellbeing, specifically to the "[promotion] of brain health in the elderly" by awakening "the neuroplasticity of the brain," necessarily warrants taking not only the brain as neurophysiologically integral in dynamically constructive ways to whole living bodies as detailed earlier but also into account primary existential facts of life with respect to the development of the brain prenatally and in infancy (Quoted from Frontiers's announcement of this Special Issue on "Cognition and Movement"). In particular, it means taking into account the fact that, barring pathological conditions, tactility and kinesthesia are the first sensory systems to develop *in utero* and that, barring pathological conditions, we all come into the world moving. In the beginning and developmentally, our cognitions are thus not linguistically tethered but bodily tethered—most basically, tactilely and kinesthetically tethered. On this basis, we form *non-linguistic corporeal concepts*—for example, of near and far, sharp and smooth, heavy and light, and open and close. Moreover, we form *if–then*

1 The following are two examples of neuroplasticity in present-day neuroscience research: "What is theorized to occur is that when the presynaptic neuron stimulates the postsynaptic neuron, the postsynaptic neuron responds by adding more neurotransmitter receptors, which lowers the threshold that is needed to be stimulated by the presynaptic neuron.... Aging and neurodegenerative diseases have been associated with a decrease of neuromodulators and may contribute to a reduction in the ability of synaptic plasticity.... The theory of synaptic plasticity has also grown to include more of the evolving complexity of synaptic communication" (Puderbaugh and Emmady, 2023). "Since the brain was found to be somehow flexible, plastic, researchers worldwide have been trying to comprehend its fundamentals to better understand the brain itself, make predictions, disentangle the neurobiology of brain diseases, and finally propose up-to-date treatments. Neuroplasticity is simple as a concept, but extremely complex when it comes to its mechanisms. This review aims to bring to light an aspect about neuroplasticity that is often not given enough attention as it should, the fact that the brain's ability to change would include its ability to disconnect synapses. So, neuronal shrinkage, decrease in spine density or dendritic complexity should be included within the concept of neuroplasticity as part of its mechanisms, not as an impairment of it.... Therefore, we propose to break down neuroplasticity into two sub-concepts, "upward neuroplasticity" for changes related to synaptic construction and 'downward neuroplasticity' for changes related to synaptic deconstruction" (Diniz and Crestani, 2023).

relationships based on our experiences, relationships that testify to the foundational animate ability *to think in movement*.[2]

Infant psychiatrist and clinical psychologist Stern (1985) pinpoints just such if–then relationships when exemplifying what he terms "consequential relationships," relationships experienced by infants, for example, "when you shut your eyes it gets dark" (p. 71). In ways akin to Stern, infant psychologist Lois Bloom terms the awareness of such experiences "relational concepts." Thus, Bloom also implicitly recognizes if–then relationships and the basic developmental phenomenon of thinking in movement (for a full description, see Sheets-Johnstone, 1999/2011). She does so when, in defining relational concepts, she states, "Children learn about relationships between objects by observing the effects of movement and actions done by themselves and other persons" (Bloom, 1993, p. 50); for example, slapping bath water causes a splash (Bloom, 1993). Furthermore, as she explicitly points out and exemplifies, relational concepts develop outside of language. They are developed based on observations of movement (Bloom, 1993, p. 50–51). Infant and child psychologist Jerome Bruner affirms this insight with his emphasis on narrative as the primary form of human discourse and the central place of action in that discourse. He writes that, when young children "come to grasp the basic idea of reference necessary for any language use... their principal linguistic interest centers on *human action and its outcomes*" (Bruner, 1990, p.78, italics in original). His point is that narrative structure is, in the beginning, concerned with movement, in particular with "agentivity" (Bruner, 1990, p. 77): "Agent-and-action, action-and-object, agent-and-object, action-and-location, and possessor-and-possession," he states, "make up the major part of the semantic relations that appear in the first stage of speech" (Bruner, 1990, p. 78).[3]

In sum, we humans learn about ourselves and our surrounding world during our developmental years by moving, by being attuned tactilely and kinesthetically to our movement, and by reaping from it an ever-increasing cognitive awareness and expansion of our practice and ability to think in movement, in effect, to being able to navigate the world in efficient, effective, and enjoyable ways.

We may, in turn, ask: can we again learn about ourselves and our surrounding world through movement as we age, thereby promoting our own health? In other words, and as asked earlier, can we learn by moving and being attuned tactilely and kinesthetically to our movement as we grow down just as we learned by moving and being so attuned when growing up? The question should be stated more specifically, for it is not just a question of moving but of dancing. For starters, it is essential to recognize that to dance is not simply to move. To dance is to be quintessentially attuned wholly and exclusively to movement, to *being-in-movement*. Thus, in dancing, movement is not tethered to accomplishing something, fulfilling a promise or an obligation, passing a test of one's abilities, and so on. Being attuned to dancing is thus substantively, essentially, and experientially different from "movement-rich exercises for the elderly." Exercising, including even "movement-rich" exercising, is essentially a specifically defined practice during which certain movements are performed: first this movement, then that movement, next this movement, and so on (Quoted from Frontiers's announcement of this Special Issue on "Cognition and Movement"). In short, to exercise is to move in conformity to a set series of movements rather than to experience a flow of movement moving through one, the latter being an experience in which *the qualitative dynamics of movement resonate exclusively and continuously in a felt whole-bodily sense*. The qualitative dynamics of movement are analytically described in terms of their kinesthetically felt qualities: tensional, linear, amplitudinal, and projectional—thus, for example, and respectively in experiential terms, as strong, curved, expansive, and abrupt. In effect, one's awareness is not on *doing* movements but on *being-in-movement*, i.e., on the felt dynamics of movement itself. As pointed out and elaborated elsewhere (Sheets-Johnstone, 1983, 2014a,b; see also Sheets-Johnstone, 2024a), familiar dynamics—tying a knot, brushing one's teeth, writing one's name, pulling weeds, typing, playing a Bach prelude, and so on—are woven into our bodies and played out along the lines of our bodies; they are kinesthetic/kinetic melodies in both neurological and experiential senses (Luria, 1966, 1973). Indeed, were someone else to brush our teeth, we would immediately recognize that someone else was brushing our teeth, not just because we were not holding the toothbrush and not only because we could actually see someone in front of us holding and moving our toothbrush but because we would also feel a foreign dynamics inside our mouth. In sum, when we turn attention to our coordinated dynamics (Kelso, 1995; Kelso and Engstrøm, 2006), we recognize kinesthetic melodies; they bear the stamp of our qualitatively felt movement patterns and our familiar synergies of meaningful movement.[4]

From this perspective, exercising is experientially a poverty-stricken, vapid form of moving compared to dancing. The difference is not a prejudiced theoretical claim but an existential reality, even a creative existential reality, and this is because movement, any movement, creates its own space–time–force dynamic, precisely by way of the inherent dynamic qualities of movement itself. In short, while thinking about movement as occurring *in space* and *in time* is not uncommon or, in particular, objective, movement definitively *creates its own space and time*. That it does so is what distinguishes, for instance, one person's recognizable walking style from another person's style. Phenomenological philosopher Husserl (1989) singles out just such recognizable individual differences when he writes about our understanding of others by way of their "typicalities":

> Personal life manifests a typicality, and each personal life manifests a different one. For certain periods, this typicality remains identical, even if the "experiences" (*the realm of the*

2 To preface the following discussion, we should note that *thinking in movement* is integral to dancing, learning to dance, and, later, learning and performing a particular dance. To dance is indeed not doing this movement now and then this movement but allowing a continuously moving dynamic form to move through you.

3 For further in-depth studies and probing essays on infants by a variety of dynamic systems researchers, see Smith and Thelen (1993) and Thelen and Smith (1994).

4 For more on synergies of meaningful movement, see Sheets-Johnstone, 2012.

> *experiential apperceptions constantly being newly formed*) of the person grow.... [I]n conformity with this typicality,... I can say that if this person finds himself in these circumstances he will behave according to type and that if the circumstances change he will still observe the type. (Husserl, 1989, p. 284; italics in original).
>
> Husserl, in fact, specifies typicality in terms of style:
>
> Every man has his character, we can say, his style of life in affection and action, with regard to the way he has of being motivated by such and such circumstances. And it is not that he merely had this up to now; the style is rather something permanent, at least relatively so in the various stages of life, and then, when it changes, it does so again, in general, in a characteristic way, such that, consequent upon these changes, a unitary style manifests itself once more. (Husserl, 1989, p. 283)

It is notable and worth recognizing that Charles Darwin wrote of style and typicality in different but complementary ways when he described individual differences among animals of the same species. In particular, he described individual differences in terms of variations, variations in agility, dispositions, temperament, and alertness, for example. As pointed out elsewhere (Sheets-Johnstone, 2022, pp. 2–3),

> Darwin begins Chapter I of *The Origin of Species* titled "Variation under Domestication" with the following observation: "When we look to the individuals of the same variety or sub-variety of our older cultivated plants and animals, one of the first points which strikes us, is, that they generally differ much more from each other, than do the individuals of any one species or variety in a state of nature (Darwin, 1968 [1859], p. 71). In Chapter II, titled "Variations under Nature," he writes, "No one supposes that all the individuals of the same species are cast in the very same mold. These individual differences are highly important for us, as they afford materials for natural selection to accumulate, in the same manner as man can accumulate in any given direction individual differences in his domesticated products." (Darwin, 1968 [1859], p. 102)

In short, humans vary individually just as all animals within the phylum Chordata and subphylum Vertebrata do. A further fact is relevant in this context, namely, the foundational importance of movement. As noted earlier, we, and other forms of animate life, come into the world moving. Movement is indeed our mother tongue: we are movement born and remain animate until we die. From an evolutionary perspective, as well as cultural and social perspectives, animate forms of life survive and reproduce by virtue of their movement—their kinetic ability to find food, their agility in fighting and avoiding predators, their concentrated and full-bodied pursuit of a mate, and, with respect to some forms, their diverse ministrations in raising young, not to mention the ability of the young to learn "how to" from their elders. It is thus hardly surprising that kinesthesia and tactility—and the earlier proprioceptive form of movement sensitivity and awareness in invertebrates by way of tactility (Lissman, 1950; Laverack, 1976; Mill, 1976; see also Sheets-Johnstone, 1999/2011)—are the first sensory systems to develop. Animate forms of life are basically tactile-kinesthetic bodies.

Another essential fact of life not only is significant but also warrants emphasis. The current practice, and even fad, of separating "the brain," notably the human one, from the body is a breach of anatomy and neurophysiology. The brain, whether of a human or any animate form of life, is indeed not a brain in a vat, a distinct and wholly separate organ, or a structured independent container or bin that functions completely on its own with no outside connections, influences, or other bodily references. In particular, and as emphasized earlier, a brain, whether of a human or any animate form of life, is part of *a whole-body nervous system*, and its afferent and efferent neural connections are essential and indispensable parts of its structure and functions. Moreover, while studying and analyzing the brain is substantively edifying, whether of human or non-human forms of animate life, it is neither valid nor truthful to make experiential ascriptions to the brain as neuroscientists Crick and Koch (1992) do, for example, when they state that the brain "infers": "If you see the back of a person's head, the brain infers that there is a face on the front of it" (p. 153); philosopher Flanagan (1991) does when he states that the brain "anticipates": "Overall, our brain is the most powerful anticipation machine ever built" (p. 319); and neurobiologist Zeki (1992) does when he states that the brain "ascertains": "An object's image varies with distance, yet the brain can ascertain its true size" (p. 69). The warning that Darwin gave in his *Notebooks* in which he recorded his research studies, questions, observations, and so on, is of seminal interest and should be given pointed consideration by those who do research on the brain. Based on his global observations of animate life and his thoughtful investigations and considerations of the research and writings of others, Darwin (1987) wrote, "Experience shows the problem of the mind cannot be solved by attacking the citadel itself—the mind is [a] function of [the] body—we must bring some *stable* foundation to argue from" (Darwin, 1987, p. 564; italics in original). As pointed out elsewhere (Sheets-Johnstone, 2010b, 2023), what Darwin meant by the words "experience shows" may be interpreted in two possible ways:

> He may have been referring to philosophers who attempt to show the nature of mind "by attacking the citadel itself" [an interpretation that may, of course, be extended to present-day scientists, many of whose "attacks on the citadel itself" include experiential ascriptions to "the brain," as exemplified above]. But, Darwin may also very well have been referring to his own extensive, highly detailed first-person experiences of animate life, experiences that showed him in person that the mind was not something distinct from the body but precisely, as he states, a function of body. In effect, animate bodies are mindful bodies.

Taking Darwin's cautionary note seriously, we may proceed to take up the question of dance, specifically addressing how dancing is a whole-body enterprise, that is a testimony to the existential reality of *mindful bodies* that move and that, in moving, create wholly qualitative dynamic forms that unfold continuously and

coherently, sustained by their own integral dynamic wholeness. Indeed, the "*stable* foundation" showing that "the mind is function of body" is movement, the movement of mindful bodies. "What!" one might exclaim. "How can movement be a *stable* foundation? It won't stay still!"

Existential realities

Husserl (1989) wrote of the unity of "body and soul," describing and exemplifying their unity and summing up it as follows: "Man, in his movements, in his action, in his speaking and writing, etc., is not a mere connection or linking up of one thing, called a soul, with another thing, the Body. The Body is, as Body, filled with the soul through and through. Each movement of the Body is full of soul, the coming and going, the standing and sitting, the walking and dancing, etc." (p. 252). To dance is indeed to engage body and soul in creating a dynamic form. In dancing the dance, the dancer and the dance are one. As discussed elsewhere (Sheets-Johnstone, 2024b),

> The aesthetic unity of dancer and dance is indeed unique. Merce Cunningham eloquently captures the ontological, even metaphysical nature of their oneness from the point of view of the dancer: "You have to love dancing to stick to it. It gives you nothing back, no manuscripts to store away, no paintings to show on walls and maybe hang in museums, no poems to be printed and sold, nothing but that single fleeting moment when you feel alive. It is not for unsteady souls." (Cunningham, 1968, n.p.)

In light of this unity, one may readily ask several questions with respect to dance and the elderly: Are older people 'steady enough souls' to engage in dance? If dancing gives you nothing but "that single fleeting moment when you feel alive," how does dancing possibly tie in with cognition and, in particular, the cognition of the elderly? Further still, how does "that single fleeting moment when you feel alive" promote brain health in the elderly?

We might begin to answer these questions by affirming first that feeling alive can be a remarkable existential experience, one that warrants recognition. The experience is perhaps the most foundational existential experience one can have. English writer Lawrence (1932) captures the affective import of that foundational existential experience in his eloquent appreciation of being alive:

"[T]he magnificent here and now of life in the flesh is ours, and ours alone, and ours only for a time. We ought to dance with rapture that we should be alive and in the flesh, and part of the living incarnate cosmos" (Lawrence, 1932, p. 200). Moreover, Lawrence affirms the authenticity of this temporally foundational fact of life by way of the living body as subject: "That I am part of the earth, my feet know perfectly" (Lawrence, 1932). Can older and elderly people affirm this fact of life—or is it beyond them? Lawrence does not mention any age limits in what he writes of the experience of being alive. Neither does Merce Cunningham mention any age limits in dancing, though we might certainly ask, as above, whether elderly people are "unsteady souls" and thus incapable of dancing and experiencing the "single fleeting moment when you feel alive."

The import of moving to wellbeing, specifically to the "[promotion] of brain health in the elderly" by awakening "the neuroplasticity of the brain," earlier took us back to infancy and the realization that our cognitions were originally bodily, not linguistically, tethered. The body is thus not a piece of equipment that lets us get about in the world; it is a source of knowledge. Furthermore, it is the anchor point of agency, of our ability to move and do or not move and do. As discussed elsewhere (Sheets-Johnstone, 1999/2011), Stern's (1985) experimental neonatal evidence of volition, that is, of agency, evidence based on the kinetic doings of identical infant twins, accords in fundamental ways with what Husserl describes as 'I govern', a basic dimension of "my animate organism" (Husserl, 1973, p. 97).[5] It testifies empirically to a psychophysical unity in the form of a tactile-kinesthetic body and, in the most basic metaphysical sense, to a kinetic tactile-kinesthetic being, a *Da-bewegung*.[6] It clearly does not accord with the sense of self as a "mental thing", an entity locked inside a head—or brain.

The research Stern et al. conducted involved conjoined twins who, before their separation at 4 months, were joined between their navels and sternums. The experiment involved determining any difference in the bodily movement of the twins when deterred from sucking their or their twin's fingers. When the researcher pulled one twin's arm away from her mouth, resulting in her fingers being pulled out of her mouth, the other twin resisted the pull; that is, *she attempted to pull her arm back toward herself*. When the researcher pulled the other twin's arm away from her mouth, resulting in her fingers being pulled out of her mouth, the first twin *strained forward with her head in pursuit of the retreating fingers*, i.e., in pursuit of something *alien* to her body. In documenting two distinctive bodily movements, the experiment documents a bodily sense of self in the form of a tactile-kinesthetic body that can move and move in self-directed ways, hence as a self-directed agent. In particular, it documents the volitional movement that springs from a knowing body that experiences both its movement and the surrounding world, which it feels directly. Such a body has the anatomical, neurophysiological, and existential capacity to respond perceptively and cognitively from head to toe. As such a body grows and matures, it does not outgrow its capacities as a tactile-kinesthetic body and a volitional agent unless medical and, in particular, geriatric conditions intervene and preclude the viability of these former capacities.

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5 There is no doubt that Husserl's (1973) animate organism is kinesthetically based: "Touching kinesthetically, I perceive "with" my hands; seeing kinesthetically, I perceive also "with" my eyes; and so forth; moreover I can perceive thus at any time. Meanwhile, the *kinesthesias* pertaining to the organs flow in the mode "I am doing," and are subject to my "I can"; furthermore, by calling these kinesthesias into play, I can push, thrust, and so forth, and can thereby "act" somatically—immediately and then mediately" (p. 97).

6 Through the methodological practice of phenomenology, Husserl identifies a further dimension of being an animate organism, namely, being a psychophysical unity: "if I reduce *myself* as a man, I get "*my animate organism*"" and "*my psyche*," or myself as a *psychophysical unity—in the latter, my personal Ego*, who operates in this animate organism, and "by means of" it, in the *external world*, who is affected by this world, and who thus in all respects, by virtue of the continual experience of such unique modes of Ego- and life-relatedness, is constituted as psychophysically united with the animate corporeal organism" (Husserl, 1973, p. 97–98).

The health value of dancing is a life-long value that is not just intimately but also integrally tied to the capacities of the tactile-kinesthetic body and its volitional movement, that is, to the capacities of a whole-body neuromuscular system from head to toe, capacities that anchor a dynamic flow of movement and thereby attest to the aliveness of a "steady soul" experiencing that "fleeting movement of aliveness" that is the hallmark of dance and within the capacity of any and all elderly who are alive and want to feel their aliveness.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author/s.

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Partnered dance evokes greater intrinsic motivation than home exercise as therapeutic activity for chemotherapy-induced deficits: secondary results of a randomized, controlled clinical trial

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Introduction: Dance has been proposed to support superior intrinsic motivation over non-dance forms of therapeutic physical activity. However, this hypothesis has yet to be evaluated empirically, particularly among populations living with neuropathology such as survivors of cancer with neurologic complications from chemotherapy treatment. Questions about motivation are relevant to clinical outcomes because motivation mediates neuroplasticity. We conducted this secondary analysis of a randomized-controlled study to begin to investigate the relationships between personal motivation and neurophysiologic effects of dance-based intervention for healthy aging among populations with neurologic complications of cancer.

Methods: We measured motivation using the Intrinsic Motivation Inventory, a validated patient-reported outcome from the psychological approach of Self Determination Theory. We assessed intrinsic motivation, extrinsic motivation, and satisfaction with intervention within a randomized controlled trial of dance versus exercise designed to alleviate symptoms of chemotherapy-induced impairment. Fifty-two survivors of breast cancer with chemotherapy-induced neuropathy diagnosis and associated sensorimotor functional deficits were randomized (1:1) to 8 weeks of partnered dance or home exercise, performed biweekly (NCT05114005; R21-AG068831).

Results: While satisfaction did not differ between interventions, intrinsic motivation was higher among participants randomized to dance than those randomized to exercise ($p < 0.0001$ at all timepoints: 2 weeks, 4 weeks, 6 weeks, and 8 weeks of intervention), as was extrinsic motivation at 2 weeks ($p = 0.04$) and 8 weeks ($p = 0.01$).

Discussion: These data provide evidence that social dance is more motivating than the type of home exercise generally recommended as therapeutic physical activity. The results inform directions for future study of the effect of dance-based therapeutics on embodied agency, neuroplastic changes, and clinically-relevant neuropathic improvement.

KEYWORDS

dance, neurorehabilitation, chemotherapy-induced neuropathy, neurologic dance training, self determination theory, intrinsic motivation

1 Introduction

As early as 1976, clinician scholars proposed dance as capable of motivating individuals to engage in physical rehabilitation (Hecox et al., 1976). Implied in this proposal is the hypothesis that dance is more motivating than other forms of therapeutic physical activity (Dhami et al., 2015), yet an empirical test of this hypothesis remains to be conducted. To address the gap in knowledge, and as one starting point from which to explore the research topic of dance, embodied agency, neuroplasticity, and health-related outcomes, we directly tested the hypothesis that dance is more intrinsically motivating than other forms of therapeutic physical activity. This study was performed as a secondary analysis within a randomized, controlled clinical trial among breast cancer survivors with chemotherapy-induced neuropathy (CIN), a population in need of novel non-pharmacologic solutions to prevent and reverse neurological complications associated with cancer diagnosis and treatments.

The ability of a physical activity program to motivate participation among individuals with neuropathology is relevant to clinical outcomes because motivation mediates activity-based therapy participation and related neuroplasticity (Cramer et al., 2011). Furthermore, aspects of dance experiences related to embodied agency – such as autonomy, connectedness, and competence – mediate motivation (Ryan, 1982; Ryan and Deci, 2000). Therefore, we propose that motivation is relevant to the research topic because it represents a measurable, mechanistic link between embodied agency and neuroplasticity. In addition to testing the hypothesis that dance is more motivating than exercise as therapeutic physical activity, we review background information relevant to the relationships between embodied agency, motivation, and neuroplasticity within the context of dance-based treatment for neurological complications of cancer.

1.1 Neurological complications of cancer

Taxane-based chemotherapy is a lifesaving treatment for breast cancer, however, the effectiveness of these agents to control cancerous cell growth comes at a price. Taxane-based chemotherapy agents have been found to cause damage to healthy cells (e.g., nerve, brain, and cardiac) among up to 80% of survivors undergoing the treatment (Song et al., 2017; Lustberg et al., 2023). Thus, survivors treated with these lifesaving agents risk a Faustian bargain: the treatment to extend life causes debilitating neuropathology. Survivors seek non-pharmacologic interventions capable of reducing the impact of chemotherapy-induced conditions such as neuropathic pain (Swarm et al., 2013), cognitive impairment ("chemobrain" or "chemofog") (Farahani et al., 2022), and premature brain aging (Koppelmans et al., 2012; Kesler et al., 2017; Du et al., 2022; de Ruiter et al., 2023).

Current standard-of-care (SOC) is to treat these symptoms with antidepressant medications, such as duloxetine, a pharmacological solution that masks, but does not rehabilitate, the sensorimotor deficits underlying symptoms (Worthen-Chaudhari et al., 2019; Mezzanotte et al., 2022). In the absence of adequate pharmacological solutions, physical activity has emerged as a leading non-pharmacological intervention capable of improving chemotherapy-induced impairments across functional domains of the human system (Campbell et al., 2019; Kleckner et al., 2021). Physical activity is defined by the American College of Sports Medicine (ACSM) as muscular work that increases caloric expenditure substantially over resting levels of energy expenditure (ACSM, 2021) and can take many forms.

1.2 Types of physical activity studied as physical medicine

Exercise and dance are two different forms of physical activity that have been studied as potential activity-based therapy. Exercise is sometimes misunderstood as synonymous with physical activity but is defined as a subset of physical activity that is planned, structured, repetitive, and performed for the purpose of improving physical fitness (ACSM, 2021). Currently, exercise is the most studied form of physical activity through which to treat the neurologic complications of cancer. Multi-modal exercise was shown to improve sensation and motor function (Streckmann et al., 2014; Zimmer et al., 2018; Kleckner et al., 2021) while partnered strength training exercise improved strength (Winters-Stone et al., 2016) among survivors. Despite this promising evidence, survivors report that conventional exercise can be challenging to motivate themselves to participate in (Frikkel et al., 2020; Kim et al., 2020). Therefore, motivation to participate might represent a critical weakness of exercise as a therapeutic physical activity option.

Dance is another form of physical activity that has been studied as physical medicine for neural deficits, also known as neurorehabilitation. Previously, we reported preliminary evidence that partnered Tango dance improved postural control among survivors with neuromotor deficits (Worthen-Chaudhari et al., 2019). Outside of study in cancer populations, dance activity was reported to increase Brain-Derived Neurotropic Factor (BDNF), important for learning and memory in the aging brain (Rehfeld et al., 2018), and decrease inflammatory biomarkers associated with Alzheimer's Disease (Wharton et al., 2021). While dance can be characterized as exercise when practice is planned, structured, repetitive, and performed intentionally for fitness goals (e.g., aerobic dance performed for cardiovascular fitness), we and others have defined dance as a form of physical activity than is distinguishable from conventional exercise (Rehfeld et al., 2018; Worthen-Chaudhari et al., 2019; Blumen et al.,

2023). Elements of the dance experience that are intentional versus incidental hold the key to differentiating between dance that does or does not meet the definition of exercise. For example, dance performed as a social, musical, and artistic endeavor – such as Argentine Tango, disco dancing, or Irish line dancing - does not fit neatly within the definition of exercise (Worthen-Chaudhari et al., 2019). While individuals performing these dances experience physical fitness improvements, fitness is incidental to the endeavor. Mechanistic aspects of social, musical, and artistic dance include neural synchrony (Basso et al., 2021), chronoception, auditory-motor entrainment, spatial cognition (Brown et al., 2005; Chauvigné et al., 2014), and interpersonal coordination characterized as activating regions of the brain involved in working memory, tactile motion processing, and social reward (Chauvigné et al., 2017, 2018). If prior assumptions are correct, then another key difference distinguishing dance from exercise is motivation (Hecox et al., 1976; Dhami et al., 2015).

1.3 Motivation mediates neuroplasticity

Neuroplasticity has been defined, broadly, as the ability of living nervous systems to remodel in terms of structure, connectivity, and function in response to stimuli that might be external and/or internal (Cramer et al., 2011). This concept overlaps with the mathematical dynamical systems approach which predicts that living systems self-organize across domains of function in response to experiential stimuli (Fogel and Thelen, 1987; Thelen et al., 2001). A 2009 NIH working group summarized the following themes for clinically-relevant neuroplasticity: (a) experience dependence, (b) time sensitivity, (c) context dependence and (d) the importance of motivation and attention as mediators (Cramer et al., 2011). We previously reviewed ways that dance-based activity has the potential to stimulate neuroplasticity through these common themes (Worthen-Chaudhari, 2011). The current report focuses on the last common theme proposed by the working group: the importance of motivation as a mediator of neuroplastic outcomes. Given the importance of motivation for outcomes, more study is needed to characterize motivational aspects of candidate physical activity-based therapies.

1.4 Motivation is measurable

Definitions from the psychological approach of Self Determination Theory can help us to characterize the motivation invoked by different forms of physical activity. This framing differentiates between motivation oriented in intrinsic versus extrinsic factors. Intrinsic motivation refers to engaging in an endeavor because it is inherently interesting or enjoyable. In contrast, extrinsic motivation refers to engaging in an activity because the endeavor leads to a separate desired outcome (e.g., symptom relief, future health benefits, financial compensation). Importantly, Self Determination Theory hypothesizes that intrinsic motivation is superior to extrinsic motivation for the purpose of promoting healthy and sustained self-regulation of behavior (Deci et al., 1994; Ryan and Deci, 2000).

According to these definitions, exercise is fundamentally extrinsically motivated because exercise is defined as being performed for the future goal of improved physical fitness (ACSM, 2021). This is not to say that exercise cannot be interesting or enjoyable, because it can. This means that the intention of exercise is to attain a fitness goal and any interest or enjoyment in the activity is incidental. Studies have used the Self Determination Theory assessment tools to characterize exercise as extrinsically motivated among neurologically-intact populations (McAuley et al., 1989, 1991; McAuley and Tammen, 1989; Tsigilis and Theodosiou, 2003; Cocca et al., 2022) but study is lacking among individuals with neuropathology. Moreover, no study to date has compared intrinsic versus extrinsic motivational characteristics of exercise versus other forms of physical activity for the purpose of neurorehabilitation design. Given the relevance of motivation to neuroplasticity (Cramer et al., 2011), such an evaluation is needed.

1.5 Motivation is mediated by aspects of embodied agency

We speculate that motivation is mediated by select aspects of embodied agency in ways that move us out of extant definitions and require futurizing. Specifically, we posit that existing psychological definitions of autonomy, competence, and relatedness (APA Dictionary of Psychology, 2024) represent components of embodied agency. Embodied agency can be conceptualized as one's sense of agency, or the feeling of being in charge of our actions (Moore, 2016), and specifically to the corporeal origins of that sense or feeling (EMBODIED Definition and Meaning, 2024). Autonomy describes the capacity of the embodied agent to make their own decisions and actions, without being told what to do. Competence refers to the ability of the embodied agent to cope with specific problems effectively. And relatedness describes the connection of the embodied agent to the environment as well as other agents in their environment. Self Determination Theory posits that personal motivation is mediated by autonomy, competence, and relatedness (Ryan, 1982), and we draw the conclusion that the measurable construct of motivation is mediated by embodied agency. More research of embodied agency is needed to understand all the ramifications of the concept. Centering agency in the body is a complex and fascinating conceptualization that promises to advance understanding of action, cognition, and physical medicine-based intervention.

Therefore, we sought to establish fundamental knowledge about motivational characteristics of dance versus exercise as therapeutic activity. Survivors of breast cancer with chemotherapy-induced neuropathy (CIN) were randomized to one of two interventions: partnered dance (dance) versus an evidenced-based exercise program (exercise). We hypothesized that intrinsic motivation would be higher among survivors randomized to dance than to exercise. If the hypothesis is proved true, then this study will represent the first empirical data supporting the prior assumption that dance is more interesting/enjoyable than exercise as therapeutic physical activity (Hecox et al., 1976; Dhami et al., 2015). As an exploratory measure, we examined extrinsic motivation to provide insight into the relative value attributed by survivors to dance or exercise in terms of alleviating their neurologic symptoms. Finally, as an additional exploratory variable, we compared satisfaction with intervention between interventional groups. Satisfaction is commonly queried in survivorship support settings to judge success of activity

TABLE 1 Participant demographics.

Demographic variable	Descriptor	Tango	Home exercise	Overall
Age (years)	Mean Median	63.6 (8.37) 63.8 [41.5, 78.7]	58.9 (10.4) 60.6 [40.8,80.1]	61.2 (9.65) 63.2 [40.8, 80.1]
Sex	Female/Male	25/1 (96%/4%)	26/0 (100%/0%)	51/1 (98%/2%)
BMI	Mean Median	31.7 (7.46) 30.4 [20.2, 53.5]	33.1 (8.97) 33.2 [20.4, 52.0]	32.4 (8.20) 31.2 [20.2, 53.5]
Race	Asian Black White	1 (3.8%) 2 (7.7%) 23 (88.5%)	0 (0%) 1 (3.8%) 25 (96.2%)	1 (1.9%) 3 (5/8%) 48 (92.3%)
Ethnicity	NOT Hispanic or Latino	26 (100%)	26 (100%)	52 (100%)
Years since last taxol	Mean Median	2.74 (1.78) 2.57 [0.416, 5.98]	3.15 (2.45) 2.92 [0.153, 7.95]	2.94 (2.13) 2.67 [0.153, 7.95]

TABLE 2 Summary of physical activity design elements per intervention.

Intervention design component	Tango	Home exercise
Recommended standard-of-care?	No	Yes
Was the movement practice musically entrained?	Yes	No
Was the movement practice socially engaged?	Yes	No
Was the intervention delivered in a group or individually?	Group	Individual
Was shared decision making practiced between participant and staff?	Yes	Yes
Total participant time commitment per intervention session	≤1.25 h	≤1.25 h
Target physical activity dose/class or session	20 min	45 min
Physical activity focus	Ease and technique of movement (balance skill, partnering, musicality)	Conditioning (balance skill, aerobic endurance, strength building)

programming. Therefore, existing therapeutic programs may have extant data on satisfaction that might be repurposed to evaluate motivation; we report satisfaction with intervention alongside intrinsic and extrinsic motivation to begin to compare between the three measures.

2 Methods

This study was approved by the Institutional Review Board of The Ohio State University and is described in full in the clinicaltrials.gov registry item NCT05114005 (registered 08/15/2021) as well as in the protocol report by Lantis et al. (2023).

2.1 Participants

Fifty-two survivors of breast cancer (BC) with chronic chemotherapy induced neuropathy (CIN) were randomized 1:1 into dance ($n = 26$) or exercise ($n = 26$) intervention arms [51F/1M; age mean (SD) = 61 (9.7) years old; years since last taxane-based agent exposure = 2.9 (2.1)]. Participant demographics per group are summarized in Table 1.

2.2 Interventions

Both interventions were designed to be completed within 1.25 h of participant time, at a frequency of twice per week over an 8-week period. Both interventions are detailed in Lantis et al. (2023) and summarized in Table 2.

The partnered dance (dance) intervention consisted of partnered, Adapted, Argentine Tango dance (AdapTango) performed to traditional Argentine Tango music (Hackney and McKee, 2014; Worthen-Chaudhari et al., 2019). This dance technique has been reported to improve balance, executive function, and biomarkers of inflammation for individuals with neurodegeneration including Parkinson Disease [citation] and prodromal AD (Wharton et al., 2021). AdapTango was delivered via in-person instruction by a former professional dancer and certified medical exercise specialist (Worthen-Chaudhari) who was certified to teach AdapTango technique by its developer (Hackney). Dance aesthetic pedagogical points (Fontanesi and DeSouza, 2021) included: musicality, ease of partnering, graviception (Fitze et al., 2024), clean execution of technique (e.g., weight shifts in time with the music), and coordination of breathing with voluntary motion. Patient-reported outcome data were recorded using the REDCap platform. We monitored participants' self-reported rate of exertion using the

20 point Borg Rating of Perceived Exertion scale, aiming for ratings that achieved no higher than "somewhat hard" (i.e., ≤13 out of 20 on the Borg scale) in either the physical or mental domain (Lantis et al., 2023). We partnered 1–6 survivors per session with an equal number of volunteers without neuropathy who were trained previously in fall prevention and basic AdapTango partnering by Hackney and Worthen-Chaudhari.

The home exercise (exercise) intervention consisted of conditioning-focused physical activity [e.g., balance skill, aerobic conditioning, strengthening, flexibility (i.e., nerve glides)] previously found to improve CIN symptoms and function among cancer survivors (Kleckner et al., 2018; Zimmer et al., 2018). This intervention was assigned as a home exercise program: qualified staff taught the exercise sequences in person with each participant, individually, allowing time for clarifications as needed, before participants were expected to reproduce exercises safely and independently at home. We addressed safety features (e.g., use of a wall, chair, or surface for safety) and provided instructional aids (e.g., pictorial aids and YouTube channel videos to demonstrate safe performance technique) (Lantis et al., 2023). Patient-reported outcome data were recorded using the MyCap application installed on participants' phones. Social and programmatic support was provided weekly by research staff, via participant's preferred form of contact (i.e., phone call, email, text message, MyCap message), to encourage, troubleshoot, and increase challenge point of the program through a shared decision-making process (Playford, 2014) between qualified staff and participants.

2.3 Outcomes

2.3.1 Intrinsic and extrinsic motivation

We administered subscales of the Intrinsic Motivation Inventory (IMI) to test for both intrinsic (primary outcome) and extrinsic motivation (exploratory outcome). The subscales of the IMI were developed and validated by several groups of scientists starting in the late 1980s (McAuley et al., 1989, 1991; Ryan et al., 1991; Deci et al., 1994; Ryan and Deci, 2000; Tsigilis and Theodosiou, 2003; Intrinsic Motivation Inventory, 2024).

2.3.2 Intrinsic motivation (primary outcome)

The 6 item Interest/Enjoyment subscale of the IMI represents intrinsic motivation in an activity just performed as a possible score of 6 to 36 with 6 = most; 18 = neutral; 36 = least interesting/enjoyable. Specific items queried include whether the activity just performed was: enjoyable, enjoyed, boring (reverse order), interesting, fun, and able to hold the participant's attention.

2.3.3 Extrinsic motivation (exploratory measure)

The 7-item Value/Usefulness subscale of the IMI represents extrinsic motivation in an activity just performed as a score of 7 to 49 wherein 7 = most; 24 = neutral; 49 = least valuable/useful. Specific items queried include whether the activity just performed was: one the participant would be willing to do again, helpful for neuropathy symptoms, beneficial, important, helped the participant to cope with neuropathy symptoms, and valuable as therapeutic for neuropathy symptoms.

2.3.4 Satisfaction (exploratory measure)

We captured satisfaction with intervention after each class using a 7 pt. Likert scale and prompt for feedback about what did/did not work per class. Satisfaction feedback was used to improve future sessions for both interventions. We administered the satisfaction with intervention measure (1 item) immediately before intrinsic then extrinsic motivation measures. The order of instrument administration did not change between timepoints.

2.4 Procedures

Participants were recruited through a process in which we mined electronic medical records for eligible individuals and worked with treating oncologists to contact those eligible, as well as through direct referral from clinicians, and flyers posted in the community.

Timepoints of instrument assessment occurred bi-monthly at the end of physical activity session in intervention week 4, 8, 12, and 16. During in-person research sessions, we used the Research Electronic Database Capture (REDCap) application, installed on laboratory laptops, to document satisfaction and motivation outcomes. For remote data capture, we used the MyCap application, a REDCap platform installed on participant's smartphones, to document adherence, IMI and satisfaction ratings, and adverse events.

2.5 Statistical analysis

A linear mixed model was applied to log-transformed scores. Data were assessed regarding normality and appropriate descriptive statistics were calculated. Results are reported on original scales. Cronbach's alpha was computed for motivation measures in combined study arms, separately for each timepoint.

3 Results

3.1 Primary outcome

Intrinsic motivation was higher among those randomized to the dance intervention for all timepoints tested ($p < 0.0001$ all comparisons, Figure 1 and Table 3).

3.2 Exploratory outcomes

Extrinsic motivation was high in both arms with a statistically significant difference at weeks 2 ($p = 0.04$) and 8 ($p = 0.01$). Grouped across timepoints, dance medians were 7–8.5, first quartile 7–7, third quartiles 11–15.5 while exercise medians were 11–16, first quartiles 9–12.8, third quartiles 15–21.5. Cronbach's alpha is reported in Table 4.

Similarly, satisfaction with intervention was high in both arms with no statistically significant differences at any timepoint ($p = 0.07$ to 0.71). Grouped across timepoints dance medians were 1–1.5, first quartiles 1–1, third quartiles 1–3 while exercise medians were 1.5–2.5, first quartiles 1–2, third quartiles 2–3.

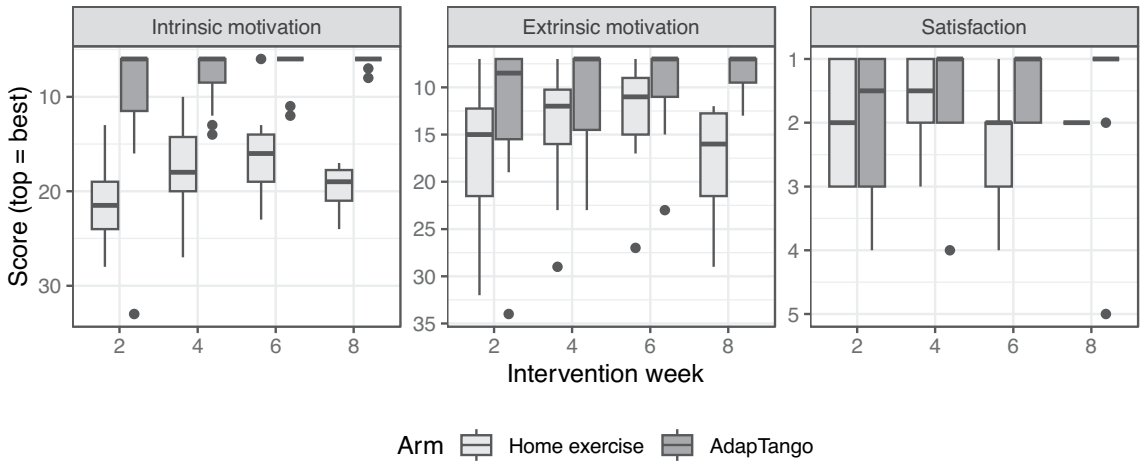

FIGURE 1
Box plots of motivation and satisfaction by week. Middle lines represent median values while tops and bottoms of boxes represent 1st and 3rd quartiles. Ends of whiskers represent the most outlying points within 1.5 inter-quartile range (IQR) of the 1st or 3rd quartiles. Dots represent outliers beyond 1.5 IQR. Intrinsic motivation possible score range is 6–36 (6 = best). Extrinsic motivation possible score range is 7–49 (7 = best). Satisfaction possible score range is 1–7 (1 = best).

TABLE 3 Intrinsic motivation values (median [IQR]) per intervention and timepoint ($p < 0.0001$ all) where possible scores range from 6 to 36 (6 = most; 18 = neutral; 36 = least interesting/enjoyable).

Intrinsic motivation	Wk4 median [IQR]	Wk8	Wk12	Wk16
Dance	6 [6–11.5]	6 [6–8.5]	6 [6–6]	6 [6–6]
Exercise	21.5 [19–24]	18 [14.2–20]	16 [14–19]	19 [17.8–21]
Between group comparison *p*-value	p < 0.0001	p < 0.0001	p < 0.0001	p < 0.0001

TABLE 4 Cronbach's alpha values for intrinsic and extrinsic motivation subscales.

Measure	Wk4 alpha (95% CI)	Wk8	Wk12	Wk16
Intrinsic Motivation subscale	0.939 (0.892–0.964)	0.846 (0.650–0.947)	0.859 (0.685–0.943)	0.940 (0.882–0.984)
Extrinsic motivation subscale	0.906 (0.766–0.959)	0.894 (0.809–0.949)	0.877 (0.615–0.953)	0.936 (0.723–0.988)
Sample per timepoint	28	29	22	15

4 Discussion

The proposed hypothesis was supported: partnered dance was more intrinsically motivating than home exercise as therapeutic activity among this cohort of survivors with BC and measurable CIN-related sensorimotor deficits. More research is needed to establish whether this effect is reproducible and generalizes to other populations living with neuropathologic impairments. However, the data provide a starting point from which to examine dance as Neurologic Dance Training practice with unique ability to motivate physical activity engagement that stimulates neuroplasticity relevant to rehabilitation and healthy aging. To describe these aspects of the dance intervention studied in a way that facilitated translation between the domains of dance and neurorehabilitation scholarship, we apply the Rehabilitation Treatment Specification System (RTSS) (Hart et al., 2019; Van Stan et al., 2019; Zanca et al., 2019).

The RTSS provides a taxonomy through which to document evidence-based neurorehabilitation interventions in ways that are reproducible, aligned with treatment theory, and facilitate future study and implementation. Interventional components are articulated in terms of conceptual frame and pragmatic specification. Once specified, the intervention can be diagrammed as treatment component ingredients (e.g., Tango walk performed in a partner practice hold to tango music) that drive mechanistic actions (e.g., intrinsic motivation), toward a clinical outcome target (Figure 2). Articulating novel interventions in this way, and in such detail, increases the chances of success for health and research professionals who may seek to study and/or implement interventions in future. Tracing the causality between treatment components and outcomes in Figure 2 makes clear the potential to effect physical skills and habits through treatment ingredients focused on internal representations of affective and cognitive

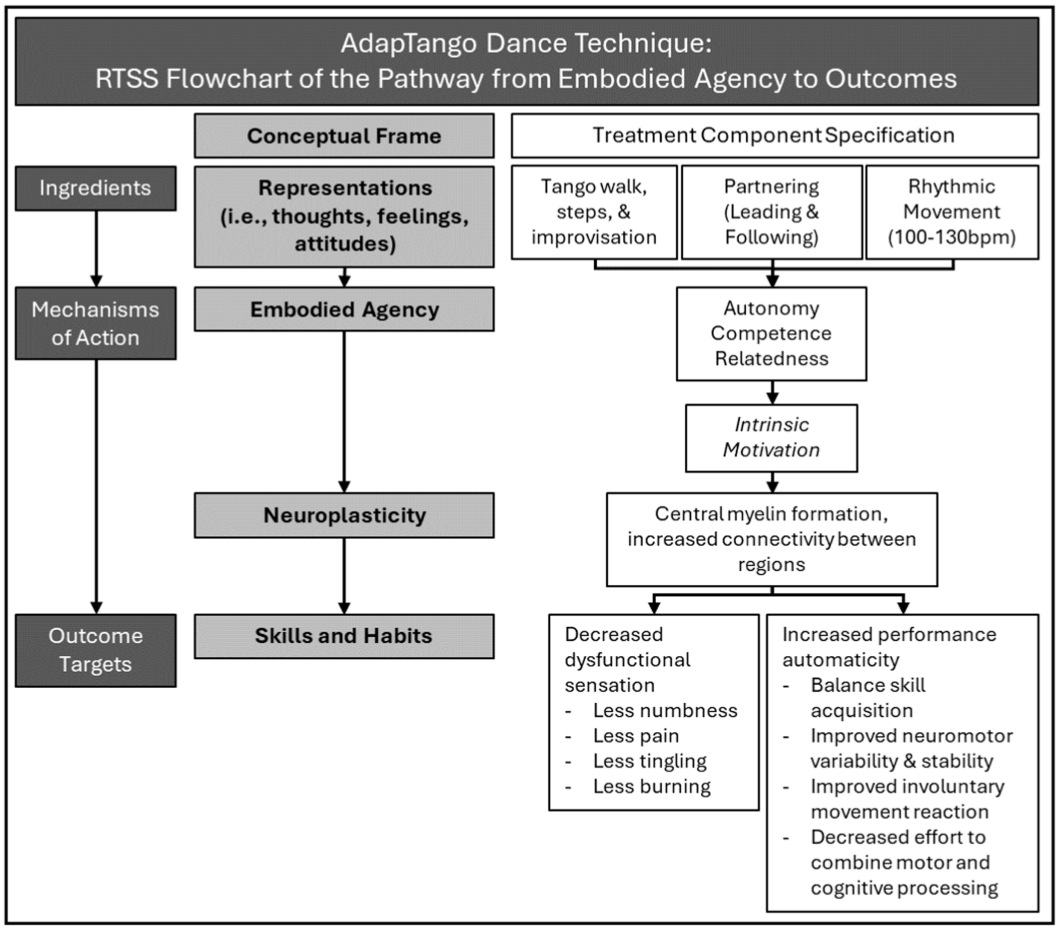

FIGURE 2
Rehabilitation Treatment Specification System (RTSS) schematic of the mechanistic pathway through which representations of embodied agency might lead to improved clinical outcomes. The variable measured for this report – *intrinsic motivation* – is shown in *italics*.

processes - such as thoughts, feelings, and attitudes during movement performance.

There are several ways in which intrinsic motivation in dance might drive measurable aspects of neuroplasticity such as central myelin formation (Lakhani et al., 2016; Faw et al., 2021) and increased structural connectivity between brain regions (Thumuluri et al., 2022). Firstly, intrinsic motivation might drive neuroplasticity via increased activity dose participation: participants could attend more sessions. More study is required to assess these results in the context of factors affecting attendance such as older age, which has been reported to increase adherence to supervised exercise (Courneya et al., 2012).

Secondly, intrinsic motivation might mediate the way that the human dynamical system attends to an endeavor. Engagement in dance-based endeavors might strengthen the coupling of goals to actions, which should improve performance automaticity as predicted by the OPTIMAL (Optimizing Performance through Intrinsic Motivation and Attention for Learning) theory of motor learning (Wulf and Lewthwaite, 2016). As but one example, artistic engagement might engage the motor and cognitive systems in unique combinatorial ways that drive motor-cognitive integration, with consequences for health outcomes. As another example, artistic engagement might serve to increase level of effort and associated clinical outcomes. Prior research characterized attention in inpatient movement therapies in terms of clinician observed "level of effort" and found that high level of effort improved outcomes at discharge (Seel et al., 2015).

A third avenue through which intrinsic motivation to participate in dance modulates outcomes has to do with relatedness: dance might support psychosocial needs through providing comfort during physical training. Qualitative research among survivors has identified the theme of comfort as a key psychosocial need and has identified social connection and personal expression as two specific forms of comfort known to support stress management associated with cancer diagnosis and treatment (Williams and Jeanetta, 2016; Kim et al., 2020; Durosini et al., 2021). Dance performed in a group or with a partner provides opportunity for exploring social connection with other survivors while dance forms that incorporate creative and/or artistic improvisational elements likely support personal expression (Hecox et al., 1976; Dhami et al., 2015). Accordingly, dance forms that provide opportunity for enhanced relatedness – that takes the form of social connection and/or personal expression – are most likely to provide comfort in ways that support psychosocial needs of survivors and facilitate activity adherence (Kim et al., 2020).

A fourth aspect of intrinsic motivation to consider involves the neural regulation and role of the neurotransmitter dopamine and the role of dopamine in play behavior. A combination of pre-clinical and

human neuroimaging studies have found that dopamine is involved in motor control, motor learning, and synaptic plasticity (Cousins and Salamone, 1996; Molina-Luna et al., 2009; Hosp et al., 2011; Da Silva et al., 2018; Koshimori et al., 2019). Because circulating dopamine is upregulated by both social (Gunaydin and Deisseroth, 2014) and musical (Salimpoor et al., 2015) experiences, dance activities that include social and musical engagement are likely to increase available dopamine in the human system in ways that potentiate skill acquisition and associated neuroplasticity. One area of emerging research with potential to elucidate the role of dopamine in intrinsic motivation, specifically, is the area of play-based learning (Kellman and Radwan, 2022). Play has been defined as fundamentally intrinsically motivated in terms of being "done for its own sake" (Burghardt, 2005) and dopamine has been implicated as a key neurotransmitter in such behavior (Siviy and Panksepp, 2011). Future research should consider commonalities in neurotransmitter activity between feelings of embodied agency and play behavior. It is possible that dance provides an avenue for physical play behavior in adults, and that resulting dance-based play invokes embodied agency, intrinsic motivation, and clinically-relevant neuroplasticity.

Indeed, the variety of avenues through which the system might spontaneously, playfully, and/or intentionally engage within the AdapTango intervention may present opportunity for participants to choose and vary the nature of their personal engagement in the activity. While dancing, an individual can tune their attentional focus to different aspects of performance (e.g., social, musical, physical) in any combination that they choose, potentially even shifting between these foci in an improvisatory way. Affording choice within physical activity interventions provides autonomy support and has been shown to facilitate motor learning (Wulf et al., 2014; Lewthwaite et al., 2015; Wulf and Lewthwaite, 2016). Therefore, the variety of avenues through which AdapTango might motivate the human system to engage represent unforced opportunities for personal choice that could prove to be contextual factors influencing neuroplasticity. Lastly, these aspects of motivated performance may mediate neuroplasticity directly, as well as create a mechanistic loop that enhances sense of autonomy, competence, and/or relatedness during performance of the endeavor, which further enhances motivation and associated neuroplasticity, looping back to re-engage the performer's sense of autonomy, competence, and relatedness. More study is needed to identify feedback loops that might be generated through arts-based therapeutic activity and the role of such reinforcing loops in clinically-relevant neuroplasticity.

More study is also needed of the interplay between health outcomes, intrinsic motivation, and the exploratory measures we report of extrinsic motivation and satisfaction. Dance was higher in extrinsic motivation than exercise at 2 and 8 weeks of intervention, in addition to being higher in intrinsic motivation at all timepoints tested. Despite this profile of higher motivation, we found no evidence for a difference in satisfaction between interventions. It is possible that the satisfaction ratings commonly gathered to evaluate therapeutic programming do not reflect the more mechanistic concept of motivation. More research is needed of these internal representations of motivation and satisfaction regarding their ability to predict neuroplasticity and associated neurorehabilitation outcomes.

Like any scientific study, this one is limited. For instance, we are limited in that we cannot differentiate between the various aspects of engagement leading to more intrinsic motivation in the dance versus the exercise intervention. Intrinsic motivation might be more attributable to social, musical, physical, cognitive, interoceptive, autonomic, artistic, or other aspect of engagement unique to the dance activity. Moreover, we are limited in characterizing engagement across the cohort because any pattern of engagement is likely to be patient-specific and to vary with time. Embodied agency represents one promising umbrella concept under which these varied avenues of dynamic system engagement might be represented and studied. Another limitation of this study is the poor diversity represented within the study cohort. Future study will address this issue and increase representation across survivors of different racial and ethnic backgrounds. Lastly, we did not study neuroplasticity directly so cannot confirm that the differences in intrinsic motivation led to corresponding differences in neuroplasticity. This is an area of future study, however, that the current research supports examining.

These data provide evidence that social dance is more intrinsically motivating than the type of home exercise generally recommended as therapeutic physical activity. The results inform directions for future study of the effect of dance-based therapeutics. More study is needed to elucidate relationships between dance-based intervention, embodied agency, motivation, neuroplastic changes, and clinically-relevant neuropathic improvement.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by The Ohio State University Institutional Review Board. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

LW-C: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. PS: Conceptualization, Data curation, Formal analysis, Funding acquisition, Methodology, Visualization, Writing – original draft, Writing – review & editing. MH: Conceptualization, Formal analysis, Funding acquisition, Investigation, Methodology, Supervision, Writing – original draft, Writing – review & editing. ML: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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This time with feeling: recommendations for full-bodied reporting of research on dance

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Collaborations that employ methods from arts and sciences to address research questions through multimodal study design are becoming more frequent, as it is increasingly apparent that complex challenges require transdisciplinary solutions. These different modalities rely on interdisciplinary exchange while involving unique expertise in associated delivery practices. In human subject driven scientific research specifically, guidelines for arts-based interventions deserve detailed reporting to allow for fidelity, replicability, and uptake of innovation and results. Details such as frequency, duration, delivery method, expected outcomes, historical precedence, and instructor training are crucial, along with nuanced descriptions pertaining to embodied aspects of specific dance or movement style(s) and adaptations made for the population or study design. This Perspective Paper outlines the current state and challenges of reporting on dance interventions and makes recommendations based on our experience as teaching artists who work in research settings alongside researchers who collaborate with dance professionals.

KEYWORDS

embodiment, interdisciplinarity, dance, aging, arts-based, arts and health, research design

Introduction

Artistic practices are an integral aspect of the health and wellbeing of communities. Human cultures throughout history have established means of moving and being together that express crucial understandings of how to live in their unique times, spaces, and circumstances (Ness, 1992). Diverse dance forms are as nuanced, complex, and multifaceted as the societies in which they develop, and the embodied knowledge they contain speaks to how various cultures construct and nurture the individuals and relationships comprising their social fabric.

Increased incidences of health and anxiety disorders globally (COVID-19 Mental Disorders Collaborators, 2021) may be linked to a deterioration of embodied practices such as group and community dances that have long contributed to the formation and maintenance of human bonds (Tarr and Dunbar, 2023). Lack of social connection has been shown to pose a significant risk for individual health and longevity, as reported in the recent U.S. Surgeon General's Advisory [Office of the Surgeon General (OSG), 2023].

Loss of community spaces and fracturing of cultural and artistic practices has direct impacts on health and wellbeing contributing to mortality (Holt-Lunstadt et al., 2015), as these play a vital role in addressing challenges associated with loneliness and social isolation by fostering creativity, engagement, and relationships.

A recent report from the World Health Organization (WHO) on the role of the arts in improving health and well-being (Fancourt and Finn, 2019) calls for policy changes introducing or strengthening lines of referral from health and social care to arts programmes through pathways such as social prescribing, which connects people to non-clinical programs and services (Poulos et al., 2019). This report, which identifies a major role for arts in the prevention and promotion of health and the management and treatment of illness across the lifespan, makes over fifty references to dance programs and their associated benefits. This reflects the growing body of published research on dance interventions, which while promising, lacks specificity and depth in reporting parameters that apply to the embodied experience of dancing.

Publications specific to the benefits of dance and cultural movement-based programs for older adults (Sheppard and Broughton, 2020), particularly in relation to conditions such as Parkinson's (PD) and Alzheimer's Diseases (AD), have increased exponentially over the last 20 years. However, the heterogeneity of practices and outcomes makes meaningful comparison and definitive recommendation impracticable (Rice et al., 2024). A lack of clarity concerning specific aspects and attributes of interventions impedes replication and contributes to confusion in both scientific and lay audiences. For example, "dance therapy" has been used in research publications to refer both to artistic dance or "Dance for Health" (DfH) programs designed to have therapeutic effect, and Dance/Movement Therapy (D/MT), a creative arts modality. While both approaches are likely to have benefits, their precise mechanisms, methods, and facilitation style could differ significantly. DfH programs are defined by the International Association of Dance Medicine Science (IAMDS) as "holistic, evidence-based activities for the individual to manage and adapt to physical, mental, and social health challenges" whereas D/MT is defined by the American Dance Therapy Association (ADTA) as "the psychotherapeutic use of movement as a process which furthers the emotional, cognitive, physical and social integration of the individual". DfH sessions are provided by "trained teaching artists" (IADMS), while D/MT requires graduate-level training and is a regulated profession in many states and countries. Confusion between these approaches makes it difficult to assess their full impact, limiting the development of targeted applications.

Research on dance interventions should (ideally) involve collaboration between dancers and dance educators, researchers, clinicians, and input from and consideration for participants. However, these stakeholders are generally accustomed to different manners of communication, primary objectives, and presentation formats, leading to crucial elements either being lost in translation or underreported. Our recent scoping review of the literature on dance interventions for older adults (Rice et al., 2024) outlines the heterogeneity of methods, populations targeted, intervention characteristics, and outcomes in dance research. In this companion piece, we outline the current state and challenges of reporting on the specifics of dance interventions and make recommendations for the dissemination of impactful science, drawing on our experience in developing and delivering dance-based protocols in research settings.

In the growing body of literature involving dance and health or aging, details related to the content and structure of the dance experience itself are sparse, when provided at all. This may be in part due to reporting conventions, but as teaching dance artists and research collaborators, we feel it is critical to acknowledge and include aspects of dance expertise and embodied knowledge within research publications. These details aid scientists in understanding the complexity that attends various dance forms, and better equip dance interventionists to translate their work to a broader community, ensuring replicability and appropriate application. The combination of physical, affective, cognitive, and social aspects of dance has resulted in a body of literature that is highly heterogeneous, with a broad range of outcome measures. Our review (Rice et al., 2024) identified over 2,000 papers and includes results from 114 studies (129 papers in total). While the bulk of these report improvements across motor and cognitive domains, the diversity in outcomes, study designs, and (lack of) details related to dance, presents substantial challenges to determining mechanisms involved in specific areas of improvement, impeding progress toward high-impact research.

Omissions in the characteristics of the dance interventions themselves are particularly glaring, as these are generally limited to reporting frequency and "style", a term which masks a wealth of details related to the how the dance form is taught, learned, modified and experienced. Our review identified 41 different dance types/styles in the included studies, and many of these collapsed several forms under a broad category (for instance, "ballroom dance" included 5–11 different forms under one type). If each form were counted individually, there would be 68 forms represented across all studies, including diverse cultural forms from around the world, and nine forms specifically adapted for older adults or those with neurodegenerative diseases. Five studies compared two dance forms, and these included group, partnered and non-partnered dance (Rice et al., 2024). This reflects the "living" nature of dance, which is always changing.

A 2011 paper (Robb et al., 2011) outlined recommendations for reporting on music-based interventions, with the goal of improving transparency and specificity in that field. These recommendations were intended to support TREND and CONSORT guidelines while accounting for the variety, complexity, and uniqueness that are vital to the efficacy of arts-based interventions. The resulting checklist included seven different components: intervention theory, intervention content, intervention delivery schedule, interventionist, treatment fidelity, setting, and unit of delivery. These elements were chosen as those that were (1) relevant across a wide range of music-based interventions; (2) essential for interpretation of outcomes; and (3) necessary for replication and translation. Taking this music-based framework as our inspiration, we offer the following guidelines for reporting on characteristics of dance-based interventions, adapted to reflect the physical practice of dancing: choice of intervention/style, interventionist, setting and equipment (mode of delivery), structure/framework of dance intervention, movement details, music, and fidelity. A checklist (Table 1) is offered in the

TABLE 1 Checklist for reporting for dance-based interventions.

Dance based intervention reporting criteria
Domain 1: Rationale for choice of dance intervention a. Existing evidence for influence of the intervention on outcomes in relevant populations b. Clear hypothesis for how the intervention affects specific outcomes in the population
Domain 2: Interventionist a. Experience with the intervention (training, background, qualifications) b. Experience with the participant population c. Role in the intervention (development? teaching? facilitating?)
Domain 3: Setting a. Space is accessible and suited to the intervention b. Spatial and material modifications were made as and if needed
Domain 4: Structure/Framework of dance intervention a. Class (or other) format? b. Group? Partnered? c. Session flow (warmup, cooldown, etc) d. Duration e. Frequency/number of sessions f. Relationship to previous/next class (learning new material vs. rehearsing)
Domain 5: Movement a. Dance form b. Objective/focus (Theme/Goal) c. Agency d. Body/Space e. Timing/tempo f. Level of exertion g. Improvisation vs. Choreography h. Modifications/adaptations employed to suit study population i. Scaffolding/skill building/continuous challenge j. Safety
Domain 6: Music a. Genre/origin b. Who chose the music and why? c. Live or pre-recorded d. Volume e. Counted? f. Relationship to movement g. Same from class to class?
Domain 7: Fidelity a. Interventionist training b. Monitoring/record-keeping/checklists c. Participant feedback d. Ecological validity—methods

spirit of Robb, Burns and Carpenter to support adoption by researchers.

Recommendations for dance-based intervention reporting

Domain 1: rationale for choice of dance intervention

There should be clear reasoning provided for specifics of the dance intervention, including (a) references to previous research using this dance form along with an adequate treatment of historical and cultural associations, and (b) a hypothesis for how elements of the form may impact specific target outcomes for the study population. In cases where there is limited or no previous research on the use of a particular form, it may be appropriate to provide justification from adjacent literature demonstrating reasons for the choice, such as examples from music or physical therapy research; details related to the condition or disease state being studied; or known responses to other creative arts and/or health interventions.

Attention to the cultural background of researchers, interventionists and participants in relation to the dance form(s) utilized and reporting on acceptability, familiarity, and meaning associated with the dance is of high importance. Many dance forms may (and do) contain embodied knowledge of cultures, times, and places, and to ignore this aspect risks leaving out crucial information. The manner of cultural transmission (teaching style) comes into play here as well—is the dance form taught or shared in a circle or are participants arranged in front-facing lines? Does a teacher model a movement that is repeated, or is there group exploration and creativity? How are key concepts demonstrated, displayed, of imbued? Does the style primarily rely on visual, auditory, or kinesthetic feedback during the learning process? Dances evolve in specific historic contexts and their manner of teaching and execution reflects these origins. Knowledge of and respect for cultural aspects of dance is key to providing adequate descriptors.

There should be a clearly stated hypothesis as to the relationship between outcomes of interests and the putative mechanisms involved, including specific characteristics of the dance form and manner of delivery (Figure 1). This explication of "active ingredients" in the intervention can help disambiguate effects related to various intervention traits such as those outlined above; it can also contribute to less ambiguity in protocol design and assist with the adaptation of dance forms to research settings. How do traits in the intervention design relate to target outcomes through engagement with various aspects of dance? This allows for greater specification of discrete mechanisms and measurables, and most importantly, demonstrates the central importance of dance characteristics in modifying outcomes.

An example of this type of detail from a study included in our recent review (Rice et al., 2024) outlines the rational for using Greek traditional dance (Sofianidis et al., 2009) in relation to the study's hypothesis and target population. The authors justified the use of this form in relation to their outcomes of interest (static and dynamic postural sway) as it involves self-imposed perturbations of the postural control system. The dance form was culturally relevant for study participants (Greek older adults), and psychosocial benefits for the specific population had been previously demonstrated. However, despite providing details related to the hypothesis and dance style, and extensive information on measurement devices and results, this study provides almost no information at all on how the dance experience was led, taught, or facilitated, making replication of findings near impossible. This leads to the next domain, which in our experience is critical, while least frequently addressed in research papers—the background and approach of the person or people leading the intervention.

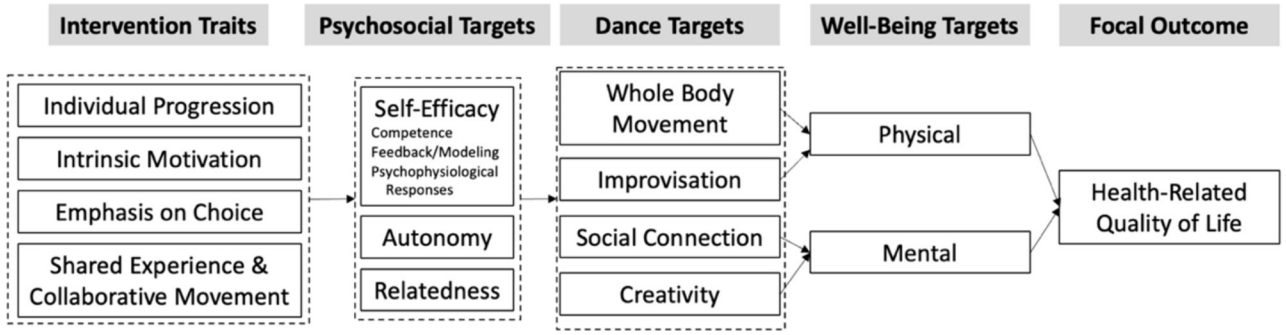

FIGURE 1
Intervention Mapping Example - Intervention mapping links specific traits of the intervention to both psychosocial and behavioral (dance) targets. These in turn are linked with other outcomes of interest, such as physical and mental well-being or health-related quality of life. Intervention mapping is one way to represent rationales related to the choice of (specific) dance forms in interventions.

Domain 2: interventionist

Research from education has clearly demonstrated that the effectiveness of both teacher and teaching style dramatically impact student learning and outcomes. Burroughs et al. (2019) identified several measures associated with higher student achievement: the teacher's experience, their professional knowledge, and the provision of opportunities to learn. These measures equally apply to teaching dance, which requires specialized skills and methods acquired through years of experience and training. A highly effective teacher or teaching model could dramatically alter outcomes; thus, the interventionist(s) role and potential influence cannot be understated in relation to the embodied aspects of dance-based interventions.

Adequate detail should be provided as to (a) previous experience with the dance or movement form used in the intervention (what is their training, background, qualifications); (b) experience with and knowledge of the participant population; and (c) clear specifications of the duties and role played in the design and delivery of the intervention itself—were interventionists involved in the development or design or the method used in the study? Who decided on the teaching/facilitation approach or pedagogical style? Is sufficient and appropriate time provided for instruction, demonstration, and feedback to participants? Descriptions of the interventionist's experience and approach should include a level of detail that supports replication. For instance, if the intervention was led by a trained teaching artist, were they teaching in a familiar style or form or was the approach used in the study new to them? In cases where the intervention is delivered by an allied health professional (such as a physiotherapist or occupational therapist), their level of experience and comfort with teaching dance, or any additional training provided to support delivery of the intervention should be reported. A study that attempts to recreate conditions previously documented may be flawed if the intervention is led by a less experienced interventionist, or one with a very different approach to teaching dance.

In terms of professional experience, knowledge is required of the participant population, to facilitate and promote safety while providing a meaningful experience with embedded adaptations as needed. If a range of adaptations are allowed for and provided in relation to various levels of mobility or experience, these should also be reported in terms of scope, frequency, and manner of presentation (for instance, if there are multiple teachers/models providing variations on a movement idea or exercise). If the interventionist(s) delivering the protocol also developed or contributed to it, they should have the opportunity to provide an outline of the class or experience structure and pedagogical approach. This should be sufficiently detailed to allow for the experience to be replicated by a different teaching team at another site. If the protocol was not developed by the intervention team, there should be an opportunity for the feedback and input of dance professionals to ensure that aspects of dance experience are suitable, adequate, appropriate, and acceptable. The provision of links to manuals or video examples, or the use of codified or culturally established forms can help clarify teaching style.

Domain 3: setting

Location of the intervention or class can affect the participant experience. If the environment is not a pleasant or easily accessible one, it may impact adherence and fidelity of participants along with the morale of the intervention staff and volunteers. A dedicated dance studio is not the same as a room in a busy community center, or a quickly repurposed clinical area. Suitable workspace is as important in dance as it is for other disciplines. Considerations can be divided into two aspects that should be reported: a description of the space itself and any challenges or limitations, and any modifications of the space made by the interventionist to enhance safety, security, or improve the experience of participants. Examples of the first type of consideration include access to parking, bathrooms, water, and the space itself, especially if there are any mobility challenges for participants. The second type of consideration includes any modifications made to promote or inhibit participation, such as ensuring privacy and/or responses to limitations impacting critical elements such as music volume or flooring.

Domain 4: structure/framework of dance intervention

This is the domain most frequently reported with some degree of detail in the literature; however, there is room for improvement as each of the elements have a wide range of nuance. The results of our review (Rice et al., 2024) found that dance studies ranged in frequency from less than one class per week to five classes a week; class length ranged from 30 to 120 min; and the duration of interventions ranged from 2 weeks to 18 months. There is also a wide range of variability possible regarding the intensity of the dance intervention, as a whole and in part. This is crucial information, as research in the field of exercise science indicates that intensity has direct bearing on the efficacy of the intervention in relation to various outcome measures, particularly those associated with physical and cardiorespiratory fitness (Garber et al., 2011). Diverse dance traditions, however, involve different structures of learning and execution. For example, some classes may start with a short warm up and then go into intense full-bodied dancing, while others may move more slowly and progressively. Some classes include a cool down while others end with learning a longer movement phrase. The flow and structure of sessions should be described in as much detail as possible to allow for replication—if there is a warm-up, what is involved and how is it conducted? It is also important to note the relationship between sessions—is there progression, repetition, or exploration? Movement transmission is not a homogenous process across cultural forms; dances can be circular or linear, improvised or choregraphed, created by the group or individuals or modeled by an expert. Intervention teams should report on the overall structure of learning and performing the dance(s) as well as relational elements that may be involved such as partnering, touch, and weight sharing. Interactional elements, if present, require additional information such as whether partners are self-selected or randomly assigned, familiarity between partners both within the class context and outside of it (dancing with a life- or care partner is a different experience than learning how to move with a relative stranger), and if there are various levels of experience in the class and/or interactions between participants with varying degrees of skill. This extends to the role of volunteers or support persons who interact with participants during the session. Are there different visual experiences entailed in the structure—do participants see and respond to each other, or only the instructor? Elements such as eye contact, touch, and auditory feedback from the teacher, other participants, or physical elements (such as tap shoes or floor percussion) could profoundly influence the experience of the dance and the outcomes of associated research.

Domain 5: movement

The types of movements practiced within various dance forms are of primary importance and are surprisingly underreported. In our scoping review (Rice et al., 2024), the range, type and quality of movement were scarcely mentioned, as it is perhaps assumed that these are standard to various forms. While we acknowledge that detailed descriptions can be difficult given the variability and sheer quantity of movements encompassed within a dance experience, movement vocabulary is of great importance for replicability purposes. Information should be provided as to the most salient aspects of movement involved in the specific practice, with enough detail that the dance experience could be meaningfully reproduced in another setting.

Characteristics of movement have been thoroughly inventoried in movement analysis and notation systems used in dance, such as Laban Movement Analysis (LMA), which includes ways of describing and documenting use of Body, Effort, Space, and Shape (Cruz-Garza et al., 2014; Tsachor and Shafir, 2019). Study designs should provide detailed descriptions of potential and recorded movement repertoires along with how movement is described and/or transcribed in the research protocol. Examples of movement descriptions could include full body movement vs. detailed hand or arm gestures, planes of movement (sagittal, horizontal, vertical), levels and level changes (floor, seated standing), various forms of locomotion (jumping, rolling, turning), temporal dynamics and range, spatial orientation, and other details related to expressivity: how the movement is performed.

Related details pertain to whether or not there is an objective focus, theme or goal to sessions or specific movements; how engagement with the movement structure interacts with self-efficacy (Waugh et al., 2023); the use of choreographed material vs. improvisational prompts; skill acquisition that is required or facilitated by the method; any modifications that are made for various motor or other abilities in the class (was everyone doing the same thing?); how were challenges faced; was there a continual sense of challenge; did the instructor/class cultivate a sense of success/safety for participants; were a range of movement choices provided or allowed.

Domain 6: music

Dance traditions and forms have different relationships with music, ranging from integral to informal, oppositional to non-existent. In the most common case, music is inextricably linked to the dance form and the two must be experienced and practiced together—in many languages, music and dance are connoted by a single term (Fitch, 2016). Dance styles or phases of learning that do not include music are less common and for this reason should take additional measures to describe how movement unfolds in time or creates its own rhythmic structure. Some dance forms may not use music at all, or at least not metered music, such as specific folk dances (Nijemo Kolo), dance theater (Butoh), and contemporary dance (Contact Improvisation). Many forms of dance shift and change the relationship with music depending on the needs of participants or setting, and silence can be used in addition to or alongside music, particularly for learning, warm-up, or cool-down phases. In the absence of, or in preparation for musical accompaniment, many dances are "counted" (5, 6, 7, 8) as a teaching strategy; as counting provides a provisional rhythmic structure, it may elicit entrainment that can impact learning and should be reported. Additional details include whether the music is live or pre-recorded, genre and selection process, volume and tempo (steady or changing), the relationship of movement to music, and if there are periods of class/session that involve teaching

without music and their duration. Reports should also include whether the music and the manner it is used remains the same throughout each class and over the progression of the intervention.

Domain 7: fidelity

Interventionists (especially teaching artists who are new to working in research settings) may require specific training in elements such as privacy, fidelity, and reporting to ensure proper execution of protocols. What monitoring is carried out to ensure treatment fidelity, to what extent is the movement protocol "fixed" or pre-determined, and what processes are in place to report deviations or adaptations? Additionally, there may be value in including teaching artists in study design and development, considerations around outcome measures, and the ethical review process, as they may have relevant concerns or suggestions that could be usefully incorporated. Training for teaching artists on specific concerns relevant to working with older populations can be crucial, as concepts such as empathy, expectations around success, the importance of not infantilizing adults, and treating research participants as dancers rather than patients can be critical for success. Having a process for receiving and responding to participant feedback helps to ensure that these criteria have been met and allows for adjustments when necessary.

Experienced teaching artists have significant insight as to how aspects related to movement and group cohesion are influenced by their work. While dance professionals and scientists may use different language to describe effects and interactions, teaching artists often have nuanced perspectives related to impacts of the intervention and how different components of the dance form or pedagogical choices influence the outcomes they see, which scientists are trying to measure. The involvement of artists as an integral part of the research team can lead to study designs that are well informed in terms of intervention detail, outcome measures, and analysis. Considering the lead artist or interventionist as an equal investigator validates their embodied expertise. This creates space for the intervention to be thoughtfully planned and executed in relation to the scientific priorities within the parameters of the study design.

Discussion

We have outlined a detailed checklist of recommendations for reporting on dance-based interventions that we hope will be useful to researchers, practitioners, and knowledge users by supporting greater transparency and transfer of methods and results in this emerging field. Our goal is to highlight the complexity and diversity of practices associated with dance that are often missing from reports in research literature—while it may not be practical to fully address every element of the checklist in all circumstances, we hope to encourage further engagement with the embodied elements of dance in research design and reporting.

We also recognize that the fundamentally embodied nature of dance does not always lend itself to lexical description. While attention to the elements outlined in the checklist and intervention mapping model above would undoubtedly contribute to deepening understandings of the nuanced and diverse practices involved in dance research and their effects, there is a need to adopt other models of research dissemination suited to capturing and portraying the finer details of dance experiences. For this to happen, we need to move beyond print journal articles as the foremost and only format acceptable for rigorous sharing of study results. As we hope has been made clear, current conventions around reporting are suited to sharing some details but poor in representing others. Reading about a dance, whether in the context of research or culture, provides little in the way of embodied detail about the first-person experience of dancing, or what it was like to *be* there. Multiplatform journals that include video such as the Journal of Embodied Research are a positive sign of evolution in this direction, as is the Journal of Visual Experiments (JoVE) which provides space for scientists to publish experimental methods in video format. A next step, which is beginning to be utilized by some authors, is the inclusion of weblinks for multimedia or video elements in "mainstream" journals as a complement to text-based elements, much as Tables and Figures serve to expand or explain elements currently.

Until such time as new mediums for dissemination become common practice, there are aspects of these recommendations that may be undertaken by various actors to improve reporting immediately. For investigators, greater attention to the suggested elements would improve the quality of reporting and facilitate adoption of protocols and better understanding of results. Collaborations between researchers with different backgrounds in the sciences or dance can be strengthened by acknowledgment and respect for equal but different forms of expertise—there is much to be learned from sharing across these fields, both of which are committed in their own ways to investigation and analysis. For journals and other forms of publication, a more rigorous attention to the level of detail provided on embodied aspects of interventions, and an openness to new forms of representation for experiential elements would facilitate uptake and understanding of dance-based interventions within and beyond the field. Engaging dance and movement professionals in the peer-review process could help to ensure that these elements are adequately described and replicable.

There will always be challenges in reporting *post-hoc* on embodied experiences, as much of the detail involved remains elusive and ineffable. Due to the diversity, complexity, and nuance involved in all instances of dancing, there will inevitably be details that elude description in any format. Capturing elements such as mood, sense of accomplishment, and other "soft" aspects can be crucial to understanding what mattered in the moment; what's more, this can vary between participants and shift rapidly even in the same person. Humanities-based methods such as phenomenological ethnography are suited to identifying these elements, and if used in combination with scientific measures and models, may lead us closer to understanding the most impactful aspects of embodied experiences. Evolving experimental designs that include both biological and affective indicators such as hormone changes, epidermal conductivity, and heart rate along with mobile neuroimaging, phenomenological interviewing, and "thick" description expanded by detailed real-time media such as video and motion capture are indicating future directions for research that has the complexity and power to grapple with bodies in motion, engaged in meaningful, creative expression.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding authors.

Author contributions

RB: Investigation, Methodology, Conceptualization, Writing – original draft, Writing – review & editing. JL-S: Conceptualization, Investigation, Methodology, Writing – original draft, Writing – review & editing. JF: Conceptualization, Visualization, Writing – review & editing. CS: Conceptualization, Funding acquisition, Investigation, Methodology, Supervision, Writing – original draft, Writing – review & editing. CH: Conceptualization, Funding acquisition, Investigation, Supervision, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Embodied agency through soft skills development in dance

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The fluidity, adaptability and complexity of a dancer's movement are often used as examples of how dance at a level of mastery is embodied. The freedom this gives the dancer to choose what and how they move is enjoyed at a subconscious level, with often tacit knowledge driving the artistic and technical brilliance. The topic of embodied agency in dance becomes more complicated when examining dance for the older person who has had little training. Embodiment is not straight forward, particularly if one examines dancing for the older adult with a neurodegenerative condition, which disrupts cognition and physical movement. Yet, as I argue, embodied agency is a key vision for socially engaged dance practices, particularly using improvisation. In the paper I examine how centring the amateur older dancer with a neurological condition means looking again at embodied agency and what it could mean in this context, as well as what the conditions are that might make it work. The paper takes the example of Dance Well, a group of community dancers in Italy that accommodates people with Parkinson's and others, including those seeking asylum. With this example I draw upon ideas from research I co-led to name some of the tacit soft skills—such as empathy and understanding and appreciating difference—developed through Dance Well's engagement with the local community, which, I now suggest, led to a process of embodied agency. I argue that in identifying this anoetic knowing, it is clear that embodied agency is not just about *mastery* of movement, but about important relational skills that are embodied and practiced through dancing, even by those with little formal dance training. I argue that moving together whilst embodying soft skill qualities may nurture an environment that could enable the transformation of relationships between those dancing and contribute to the creation of an important and meaningful activity within the community. In this way, the paper outlines ideas on how embodied agency through dancing may contribute to a vision of social justice and a characterization of embodiment that emphasizes the recognition of each other's humanity.

KEYWORDS

dance, Parkinson's disease, embodied agency, soft skills, social justice

Introduction

In this article I focus on the idea that embodied agency can be harnessed through the practicing of soft skills in the context of a specific dance programme that invites people with Parkinson's and others to share creative movement. The article is divided into sections that take the reader through my argument. First, I lay out my definitions of both soft skills and embodied agency and contextualize them in relation to the current literature and disciplinary foci, as well as in relation to dance. I suggest that there is a gap in knowledge in linking both embodied agency and soft skills together within the discipline of Dance Studies, and when examining dance practices. Second, I outline the project, Empowering Dance and its case study of Dance Well: Movement Research for

Parkinson, which gave impetus and evidentiary grounding to my thoughts in this area. I then go on to examine the concept of embodied agency as it currently pertains to dancing in a professional context, and I outline my counterargument following this, seeing the problems for community dancers, particularly those with Parkinson's, and I suggest a different approach through the lens of soft skills. I use the case study of Dance Well to expand on this argument and conclude that understanding embodied agency through soft skills could lead to appreciating the contribution dancing might make to a vision of social justice and a characterization of embodiment that emphasizes the recognition of each other's humanity.

Introduction to soft skills and embodied agency

Soft skills are the patterns of thought, behaviors and qualities that enable interpersonal relationships to thrive and support the navigation of personal emotions. The article is particularly interested in the connection between the idea that soft skills can emerge and develop within some dance practices, particularly in community settings, and the impact of dancing on all involved, which crucially might include a development of embodied agency. The notable quality of many soft skills is that, because the body plays a central role in navigating emotions and the dynamics of interpersonal exchange, they often emerge in and grow through the body and by encountering others in space. There is therefore a potentially interesting relationship between dancing—the playful, creative and aesthetic movement of the body as it connects to others moving—and soft skills, the embodied support for relationships to flourish. The article goes further in suggesting that whilst it would not necessarily be common to talk about embodied agency in relation to community dancers, who dance for fun rather than professionally, embodied agency could be the element of impact for community dancers that is felt through a dance process where soft skills are championed.

As a starting point for thinking about embodied agency, I take Noland's (2009) definition. She writes that embodiment is,

> the process whereby collective behaviors and beliefs, acquired through acculturation, are rendered individual and "lived" at the level of the body. *Agency* it follows, is the power to alter those acquired behaviors and beliefs for purposes that may be reactive (resistant) or collaborative (innovative) in kind (Noland, 2009, p. 8–9).

I take the idea that collective behaviors and beliefs are seen within the sub-cultures formed through dance practices, as well as in everyday activities. It should be noted again here that soft skills also concern behaviors and thoughts cultivated within practices and sub-cultures.

Embodiment is a large expansive topic tackled from various fields of thought. In particular, there has been strong representation from work within the Sociology of the Body, with Shilling (for example, Shilling, 1997, 2013, 2016; Wacquant, 2004; Aalten, 2007; Crossley, 2007; Turner, 2008; Frank, 2013). Some of this work has attended explicitly to dance case studies, seeing it as a physical and embodied activity within a wider social system. The main thrust of this work has been to counteract traditional schools of thought in Sociology that have neglected the body's role within social systems and activities. It is no co-incidence that Dance Sociologists, such as Thomas (1993, 2003), reiterate this claim as it pertains to the marginalization of dance within society and within the arts. Key within Sociological and Anthropological thought has been the seminal work of Mauss (1935) whose work on body techniques set the stage for expanded thinking within the area of embodiment (for example through Crossley's work).

The areas of Cognitive Science and Neuroscience have also contributed to the concept in examining the neural mechanisms for conditions of embodiment and the work of Calvo-Merino, Jola, Glaser and Haggard (for example Calvo-Merino et al., 2008 and separately) is key to this area in looking at professional dancers, as is Batson and with Wilson's (2014) work examining cognition's role in Somatics. Within Dance Studies Grau's (2005, 2012) work in the Anthropology of Dance stands out for its sensitivity to differing cultural conceptions of body, embodiment and dance and how embodiment of the moving body is crucial to understanding certain peoples and ways of life. Philosophy of Dance has been key in its examination of the concept of embodiment and the experience of dancing, with Sheets-Johnstone (1966), Fraleigh (1987), Parviainen (2002), Warburton (2011), Katan (2016), and Bresnahan et al. (2020) as examples of authors who have introduced dance into philosophical disciplines, such as phenomenology and epistemology. From a Cultural Studies angle, Noland (2009) has in particular been useful in expanding the discussion on embodied agency, gesture and dance explicitly.

Soft skills as a subject area has had attention from different disciplines to the ones covering embodiment and embodied agency. Most of the thought on this topic has emanated from Business Studies and Management Studies (see for example Andrews and Higson, 2008; Kautz et al., 2014; Yoke and Ngang, 2015; Marin-Zapata et al., 2022) where the debate has been to define the term and to examine how soft skills may help in leadership training and leadership success, as well as how to train business students and early career graduates in soft skills. Additionally, the European Union has commissioned research on the topic of soft skills, with a view to incorporating soft skills into policy (see for example, Council of Europe, 2016; Rodrigues et al., 2021), as have other international bodies, such as OECD (2018) and UNICEF (Hoskins and Liu, 2019). The interest in soft skills to be integrated in high level workforce development policy was underlined by the 2023 report by the World Economic Forum, which declared that soft skills—such as negotiation, understanding and appreciating difference, care and patience—were the most important set of skills in the workplace now and in the future. The Organization for Economic Co-operation and Development (OECD) went further arguing that to navigate a complex and uncertain world, soft skills are vital (OECD, 2018).

Despite this interest at policy and academic levels, soft skills (sometimes called life skills, or 21st century skills) have hardly been recognized in dance practice and scholarship, despite these skills being used by dance artists (Empowering Dance, 2020). The European Commission funded Empowering Dance 2018–2020 project identified soft skills that are used within contemporary

dance practice with non-trained people. These skills included soft skills that are primarily introspective, such as patience, self-efficacy, self-perception, goal setting, critical thinking, as well as soft skills that are primarily inter-relational, such as conflict resolution, negotiation, active listening, empathy, dealing with uncertainty and complexity, taking care of others, flexibility and adaptability and understanding and appreciating differences (Empowering Dance, 2020). There is scant literature on soft skills and dance, with one review of the benefit of soft skills as part of dance pedagogy in China (Buck, 2022) and a research study on the use of soft skills in leadership development whilst practicing folk dance at a university in Peru (Bedoya et al., 2022). There has been one other European Commission funded industry-focused project on soft skills and dance (Moving into Soft Skills, 2024), led by a consortium of somatic practitioners. Its approach is to provide digital tools to help facilitators and educators explore the presence or absence of soft skills through using the body. Additionally, the British dance artist and coach Wookey (2024) led a small industry-focused research project (accessed 2024) that explored how the soft skills of dancers could be transferred to other professions. All of these studies point to the importance of the moving body when developing soft skills.

Additionally, notwithstanding excellent work on embodied agency in various fields and in soft skills there has been hardly any overlap between the concepts in Dance Studies, despite this being fertile ground. The closest the discussion comes is in the writing on embodied learning where there are examples of the importance of the body and physical practice in skill learning (see for example Zarrilli, 2004; Andersson and Österman, 2015; Anttila, 2016; Ravn, 2022). There is therefore a gap in knowledge and understanding of soft skills as it pertains to embodied agency through dance.

The case study and approach

The impetus for my discussion is the dance industry-led project, of which I was part, mentioned above, Empowering Dance: The Soft Skills Teaching and Learning Approach (2020–2023), funded by the European Commission through Erasmus+ and involving as collaborators European Dance Houses, dance artists and community dancers from across the European Union.[1] The goal was to help dance artists recognize and articulate their soft skills. This culminated in creating the online *Soft Skills in Dance: A Guidebook to Enhance your Practice* (Empowering Dance, 2022), marking the contribution of dance to the incubation and development of soft skills. The industry orientated guidebook, co-authored by myself and dramaturg Monica Gillette with the Empowering Dance consortium, was a series of tools and reflective tasks for professional dance artists to identify, articulate and develop their soft skills.

The collaborating team included five dance artists and four participatory dance groups. Unlike usual research projects, the dance artists and groups were not subjects of research but collaborators in developing the guidebook and contracted to do so.[2] The research and development was characterized as participatory action research where dance artists led the community groups in weekly dance sessions and then had bi-monthly sessions of reflection, exchange, dialogue and analysis on soft skills development with myself, Gillette and the consortium evaluator who had also witnessed one third of the sessions. This happened over a period of 9 months, with the first 4 months of sessions conducted online due to COVID-19 pandemic lockdown situations in all the participating countries.

The sessions drew out themes from each dance practice, for example, themes of leadership, trust, vulnerability, taking care, and then related these themes to soft skills so the dance artists could identify and articulate them in their practice. Through this discussion, we discovered the enabling conditions necessary for the development of soft skills and the attitudes and values needed to engage socially, as well as focusing in on what dance practices specifically offer to make soft skills flourish and what approaches are needed so that they are recognized and communicated (Empowering Dance, 2022).

Throughout the project the dance artists' use of language and modes of communication with their groups and in their journals was analyzed. The process was dynamically reflective, where the individual dance artist was given space for experimentation and individual learning, which through dialogue, became the basis for generating shared knowledge.

One of the community groups, or case studies as they were called, was a longstanding group called Dance Well: Movement Research for Parkinson, or Dance Well for short. The core founding group is situated in the Civic Museum of Bassano del Grappa, Northern Italy, but for the case study it also used another of its sites in the Vento region, the Teatro Civico in Schio. These groups were already in existence and fluctuated in numbers depending on guests and month, but consisted of around 25 core members in Bassano and 15 in Schio. Of note, Dance Well's approach to dance and informal network has expanded in the last three years to different locations within Italy, Europe and Asia and is an influential approach in the field of dance for Parkinson's internationally.[3] Dance Well promotes dancing in artistic contexts and within spaces of cultural heritage, such as museums. It is aimed primarily, but not exclusively, at people living with Parkinson's. In fact, the non-exclusivity gives it an intergenerational energy that

1 Funded by the European Commission, Erasmus+ programme, the Empowering Dance consortium consisted of Kampnagel/K3 Tanzplan Hamburg (lead), La Briqueterie CDCN Val de Marne, CSC Bassano del Grappa, Dansateliers Rotterdam, University of Roehampton London, Croatian Institute for Movement and Dance Zagreb, University of Zagreb.

2 Ethical consideration and permission were managed through the written consent, care and data protection processes and policies, and legal contracts drawn up by each consortium partner who organised the dance sessions and hired the dance artists for the project, as well as being overseen by the project lead partner Kampnagel for the consortium as a whole. Ethical action was an ongoing process of checking in with collaborators, of "held" conversations with Kampnagel's dramaturg and evaluating the systems and processes at 3 monthly intervals.

3 Dance Well International's network reaches Italy, France, Germany, Lithuania, Czech Republic, Hong Kong and Japan. Another, much larger international network, with certified teachers and groups, is Dance for PD. Dance for PD is based in New York and has many hundreds of affiliated members around the globe and operates a slightly different model of working to Dance Well.

envelops a larger section of the local community (including in Bassano del Grappa people seeking asylum housed there) than seen in other dance for Parkinson's groups. It is usual for several dance artists to contribute to facilitating the sessions, where movement improvisation and exploration is prioritized. A teacher training programme is also an important component.

In reflecting on what this specific case study brought up, I see a number of interesting elements that are pertinent to a discussion on embodied agency in relation to soft skills. The specific context of community dancers with Parkinson's helps me to elucidate a different understanding of embodied agency, one which is impactfully connected to soft skill development. The following discussion is not the results of empirical research into the connection of embodied agency with soft skills, but a reflection on this connection post-study in soft skills development. In laying out an argument that brings both concepts together, I provide an original approach to thinking about how it could be possible to discuss embodied agency in the context of socially engaged dance with people who have a neurodegenerative movement disorder. At the same time this essay provides a new examination of soft skills as they appear in dance practice and their potential for social inclusion and community building.

Embodied agency in the professional dancer

The fluidity, adaptability and complexity of a dancer's movement are often used as examples of how dance at a level of mastery is embodied. The freedom this gives the dancer to choose what and how they move is enjoyed at a subconscious level, with often tacit knowledge driving the artistic and technical brilliance. There is a great accomplishment here that facilitates power and agency (Zarilli, (2000 [1998])). Dance scholar Levin (1983) studied the ballet dancer, a performer of virtuosic gracefulness. Levin argues that becoming seemingly weightless in the eyes of the spectator and playing with the suspension of time is the mastery of that art form. It is the "elite" dancer with many years and hours of experience that may accomplish these feats. It is only by inhabiting the technical form so completely without conscious thinking through that the mastery of the movement qualities can happen (Levin, 1983; Zarilli, (2000 [1998])[4]).

Actor trainer and theater scholar Zarrilli (2004) explains more. He uses the example of learning the Lion Pose in the Indian martial art Kalarippayattu to illustrate the embodied mastery of movement that occurs at a sub-conscious level. The first stage of learning is a conscious action, where one learns how to place one's feet, adjust the gaze and spine. Skills are acquired when actively, and reflectively, responding to the teacher's guidance as to how to adjust the placement of the body for effective movement. This skills acquisition in turn allows the performer to move to and from the Lion Pose to other movements seamlessly. The performer now knows how to use the Lion Pose and can effectively master the movement as it becomes intuitive:

> The individual's proprioceptive sense allows one to make subtle, minor adjustments to the very act of placing the foot without thematizing the adjustment, i.e., one's bodymind "intuitively" adjusts as one moves (Zarrilli, 2004, p. 659).

Sociologist Shilling (2016) adds that mastery of a craft is also a matter of sensing differently, as well as cognitively and physically learning a system of movement. He argues that the senses are employed to guide the expert to problem solve when the unexpected happens; that the senses may guide the dancer, boxer or soldier to know how to adjust his or her body and its movement. The senses play an important part of the intuitive or "tacit" knowledge about navigating the world or stage when the expert is faced with new conditions or other movers. Philosopher Dewey (1925) termed tacit knowledge as "anoetic occurances", namely "the 'subconscious' of human thinking" (p. 299). He poetically explains:

> we continually engage in an immense multitude of immediate organic selections, rejections, welcomings, expulsions, appropriations, withdrawals, shrinkings, expansions, elations and dejections, attacks, wardings off, of the most minute, vibratingly delicate nature. We are not aware of the qualities of many or most of these acts; we do not objectively distinguish and identify them. Yet they exist as feeling qualities, and have an enormous directive effect on our behavior.

He continues:

> They give us our sense of rightness and wrongness, of what to select and emphasize and follow up, and what to drop, slur over and ignore, among the multitude of inchoate meanings that are presenting themselves. They give us premonitions of approach to acceptable meanings, and warnings of getting off the track (Dewey, ibid).

Or as Chris Shilling more succinctly put it, that knowledge, or more precisely that *knowing*, which exists "independently of conscious thought, embodied at a pre-conscious level as an awareness, intuition or practical ability" (Shilling, 2016, p. 1214). Dewey underlines the importance of anoetic knowing for intuitive judgements in action. In relation to professionals dancing, this has been characterized as "on-one's-feet, thinking-while-doing" (Bresnahan, 2014, p. 92) and manifested in, what dance philosopher Aili Bresnahan calls "improvisatory artistry" (Bresnahan, 2014, p. 85). The improvisatory artistry requires spontaneous, intuitive (yet grounded in experience) choice making that Bresnahan argues is agentic. In essence, the embodied agency afforded by experienced dancers allows them to move quickly, effectively and efficiently, as well as to create meaning and even wonder and awe for others through their actions.[5] There are several terms in use currently for tacit knowledge. I shall use "anoetic knowing" as it is commonplace

4 This view is seen as current thinking in dance, but seen especially, for example, in discussion with dance scholars using Bourdieu's theory of habitus (see for example Crow, 2020), or theories of improvisation (see for example Albright and Gere, 2003), or even as in McKinney et al. (2009) with AI and dance.

5 This is not to say that expert movers do not think in action. See Montero (2016) for a cogent explanation, and also discussion of Dewey's work on the connections between noetic and anoetic knowledge in Shilling, 2016.

within several disciplinary circles, although it should be noted that some of the authors noted below prefer the term tacit.

I have already mentioned that experienced movers move with anoetic knowing. Anoetic knowing is particularly prevalent in embodied practices, such as dancing, where it is the knowing through doing which builds understanding and is learnt through practicing (Andersson and Österman, 2015). Please note the emphasis on actions/verbs in this definition. Not learnt through theory or conscious thinking alone, anoetic knowing is acquired through the process of regular action (Polanyi, 1967). In learning through experience and doing, the embodied understanding and knowing built up is nearly always captured and processed beyond the need for words and detailed description and categorization, as befits the acquisition of technical skills (hard skills). Andersson and Österman (2015) give a case study of a person learning to sail. In the example, although sailing requires a specific technical skill that can be learnt through a manual (a worded description), it is only by experimenting through movement and in the specific weather conditions that the sailor student discovers the gap in technical know-how and what is required to achieve a particular move or to surmount a specific challenge. Dancing in any technical form is the same. Watching any rehearsal, the observer will hear the teacher suggest tiny shifts of weight, positioning, gaze and feeling. The dancers have to experiment and sense what these "nudge words" of the teacher could form in their own body to create a journey toward the desired outcome. As Andersson and Östman note,

> the idea that "the pupil must discover it for himself"…means that he or she has to learn to functionally coordinate his or her experiences to *create* intelligent action. When human beings respond to their internal and external environment they then have the possibility to expand their experiences and further their tacit knowing. In other words, they grow (Andersson and Österman, 2015, p. 277).

This process of anoetic knowing is gradually ingrained, not solely through following the manual but through experimenting with the body's own grasp of sense-making. Within a specific context where inflections of movement give sense and create meaning to those who inhabit that context, or institutional setting, the moving body is the site of learning (Dewey and Bentley, 1946; Polanyi, 1967; Gourlay, 2002).

Not only is anoetic knowing embodied within learnt action, it is also embedded within institutional—cultural—knowledge (Andersson and Österman, 2015). Anoetic knowing is not peculiar to an individual's internal processes but is often a shared understanding between people within an institution (or cultural practice). Despite the difficulty in articulating anoetic knowing, it is understood in the act of trying to do it, and those who practice a specific skill or action understand what that action is getting at. Anoetic knowing is a process that is meaningful alongside the embodied rules of action and cognitive beliefs adhered to by the people (for example contemporary Release-based dancers) who practice a particular skill (for example, contemporary Release technique) (Polanyi, 1967). This is important if anoetic knowing is to be characterized as sense giving and sense making (Polanyi, 1967).

Sense-making is not just about creating and developing meaning by giving form to the technical manual. It is about also bringing sensory and sensual contributions to the effort of sense-making through embodied action. Most scholarship on anoetic knowing is based around doing and practice. It is functional. However, it is important not to neglect the fact that embodied knowing is also affective because the senses are the vehicles from which the body is in communion with its internal and external worlds. The moving body creates sense through the sensory, sensuous and emotional resonance of its inflections. No more so than in the aesthetic realm of dancing where the emotional and sensorial power of the moving human is highlighted. Dance scholar Vida Midgelow points out that specifically the embodied knowing of a dancer is her sensuous and sensory movement experiences "be it her particular mode of physical knowing that comes from dance training or that which is found in felt, emotional, critical or memorial realms" (Midgelow, 2013, p. 3). The dancer draws on his or her own experiences in life to feed into the technical know-how of movement.

Embodied agency in the community dancer

The topic of embodied agency in dance becomes more complicated when examining dance for the older person who has had little training, who may have joined a dance project organized for his or her community. Given the discussion above one could surmise that embodied agency may only become possible with many years of practice. Yet embodied agency is a key vision for socially engaged dance practices, particularly using improvisation. Perhaps to begin to explore this one might seize on Midgelow's description of embodied knowing above where sensory and affective experiences in life (and learnt culture) color the "doing" of movement.

Although there are two distinct areas of socially engaged arts practice[6]—one centered on anti-institutionalization and social destabilization, and the other on interdependent support and social imagining (Jackson, 2011)—I will concentrate on the latter where most socially engaged dance sits (Bannon, 2018). Socially engaged dance practices, including community dance, are those that involve communities and individuals at various decision-making levels, as collaborators, co-creators, or engaged movers. It is co-operative art making (Matarasso, 2019). Additionally, and because of the emphasis on sharing, socially engaged dance practice aims to be a "transformative and generative participatory practice, which enlarges what is possible in a territory or ecology. It supports processes of inclusion and cohesion, and is active in promoting aspects of social justice" (Empowering Dance, 2022). In other words, socially engaged dance broadens the aims of participatory or choreographic practices. It is concerned with building connection, relationship and community that ripples out from the dance

6 Socially engaged arts practices are held within the umbrella term participatory art, which has more variety of definitions and political stances, as laid out by Bishop (2012). Although definitions and political traditions cross art form, dance has its own trajectory, ideologies and journey.

practice into the places where it is hosted. As such, dance becomes a form of activism (Tate, 2024). Dance scholar Fiona Bannon writes that,

> what citizen art, activist art, and participatory arts have in common is that they work to stimulate the active artistry and intellect of others. They tend to build infrastructure and connections that forge visible and sustainable bonds with people's worlds that endure beyond the political fashion of any given moment (Bannon, 2018, p. 100).

What Bannon alludes to in her last comment is that socially engaged art, and as she goes on to investigate, dance, will operate beyond the call for instrumentalization of the arts and their adherence to specific local or national governmental policy.

Embodied agency is important in the context of socially engaged dance because the body is at the center of the practice-as-activism. Dancing is the act of moving with and through the body. The body is also integral to a human's identity and mode of being, as well as being a site of traumatic, as well as joyful and mundane experiences and cultural inscription (Noland, 2009). To pick up on Midgelow's description, the lived experience is brought to bear in socially engaged dance practices, often more so than in artistic exploration by professional dance artists. Since the intention in these body-based practices is to build connection, community and relationship through shared decision-making, embodied agency becomes an intended consequence, at least theoretically.

I say theoretically, because although embodied agency becomes the important intention, there is still the challenge of realistically corporeally creating and inhabiting agency within a dance context.[7] Embodied agency is not straight forward, but since it is a key intention in socially engaged dance practices, I would like to take a specific example to explore further what embodied agency could mean in that context, as well as what the conditions are that might make it work.

I would like to focus in on the amateur older dancer with the neurological condition Parkinson's. There are a rapidly growing number of dance programmes and initiatives for people living with Parkinson's around the world, some of which come under the umbrella of socially engaged dance practices and which I have studied over a number of years (see for key examples Houston, 2011, 2015, 2019, 2020a,b; Houston and McGill, 2013). As mentioned in the introduction, the dance group for people with Parkinson's I am focusing on in this discussion is Dance Well, Italy. It is a programme that exemplifies many of the values of socially engaged art and is not purely a series of dance classes taught to people with Parkinson's. It is strategically more radical than that. Dance Well provides dance sessions and events for people with Parkinson's and other citizens in the city, led by a rotating group of dance artists and situated in a site of cultural heritage. Using mainly improvisatory methods, the sessions increasingly encourage the dancers to make artistic decisions, gain confidence in their own way of moving and to connect with a diversity of people curious to dance with them. Bassano also holds artistic residencies for contemporary dance artists creating work and many of these artists are invited to also work with Dance Well, and even creating productions on the group. This is a longstanding group, who have been together for many years and yet continually welcome in itinerant artists, refugees and others to dance. It is of note that people with Parkinson's dance with a larger group of people without Parkinson's, which includes those who were in some other ways socially marginalized or minoritized. As this article will expand later, practicing soft skills through dancing did not just impact the embodied agency of people with Parkinson's, but others around them too. But whilst the discussion later will reference the wider group who are welcomed into Dance Well, I will emphasize those with Parkinson's in this section, as a way of giving focus to a specific example where embodied agency is often lost.

Parkinson's is a condition that gradually pushes away embodied agency: the "technique of the body", to use Mauss's (1935) terminology, is often in daily life discordant and out of control. The mastery of every day movement breaks down. Parkinson's is clinically diagnosed through identifying two out of the three cardinal symptoms, bradykinesia, tremor and rigidity of muscles (Adams and Victor, 1993; McAuley, 2003). In addition, there are many other symptoms that can occur including postural instability (McAuley, 2003). Parkinson's increasingly affects the ability to walk normally and without falling over or freezing (getting stuck) (Allen et al., 2013). The condition can dimmish vehicles for communication, such as speech, writing and facial expression (Kim et al., 2009). There are many other symptoms that can occur in any one individual with the condition and these impact social participation and confidence in navigating the outside world (Solimeo, 2009; Houston, 2019). Particularly relevant to the topic of this article, Parkinson's gradually diminishes automatic movement—movement accomplished without conscious thought—as well as multitasking (Nieuwhof et al., 2017). The basal ganglia in the brain are the sites that create automatic movement and that are affected by Parkinson's. Journalist, Palfreman (2015), who has Parkinson's himself, likens the lessening of automatic movement to driving on a different side of the road to normal. Reflexes, operated from the basal ganglia, cannot be relied on and conscious thought from the cortex is needed to concentrate on the mechanics of driving. This slows a driver down and makes them more vulnerable to unexpected dangerous events on the road. The challenge of having to concentrate on movement that should be automatic makes its mastery even more difficult for people with Parkinson's.

One can conclude that the "doing" through old, anoetic knowing does not come easily, and less so as time passes. The experience of engaging with the world and with dance could be seen as "fractured" (Shilling, 2016) for the person with Parkinson's. Studies suggest that people with Parkinson's can still learn, but slowly and with substantial limitations (Nieuwboer et al., 2009; Marinelli et al., 2017), most notably in retaining new skills and learning that require attention and the use of cognitive strategy, rather than relying on pre-conscious thought (Marinelli et al., 2017).

Nieuwboer et al. (2009) note that cueing may aid in retaining learning, although the person may also be reliant on cueing to keep learning. Marinelli et al. (2017) note the positive effect of exercise on

7 The challenges of reaching the aims or ideals of community dance have been pointed out by Houston (2005) and Wise et al. (2020).

symptoms of Parkinson's, particularly those which do not respond well to medication or surgery, such as those affecting gait, posture and balance, and that furthermore exercise may further improve motor rehabilitation "by adding sensory stimulation, cueing, and music in pleasant social contexts and environment that increase task enjoyment". Marinelli et al. quote Volpe et al. (2013), who have studied the effect of Irish folk dance on people with Parkinson's. To underscore his conviction, Volpe has notably collaborated with Dance Well for many years, inviting people with Parkinson's to dance at his clinic in the nearby Fresco Parkinson Center. Marinelli et al. (2017) observe that the strategies within the exercise activity will be important for accomplishment of the movement. These strategies include, as Nieuwboer et al. also point out, external cueing, feedback, as well as reward and motivation. They conclude that "this type of approach produce[s] good results probably by allowing the execution of correct movements under attention-volitional control, with a direct access to cortical resources and limiting the use of automaticity mechanisms that are affected by PD" (Nieuwboer et al., 2009). In other words, these strategies are seen particularly in dancing sessions where the facilitator demonstrates the movement and allows participants to copy them and where there is instant feedback and motivation. What this small body of research points to is that despite people with Parkinson's developing a skill learning deficit from quite early in the progression of the condition, exercise, such as dancing, might provide appropriate external help to enable people with Parkinson's to keep learning, or at least to accomplish new movement.

But despite including external cueing, feedback and reward, dancing does not normally get to the state of mastery that is described above. Additionally, it takes a very skilled facilitator to assign agency to a person that is being assiduously cued in movement. What is somewhat more useful to embodied agency is the fact that these tasks are enjoyable, bringing a felt sense of pleasurable purpose and motivation. I suggest, though, that to explore embodied agency further we need to look at this differently and in a new way. I propose that it is through nurturing soft skills within dance initiatives with people with Parkinson's that it might be possible to explain embodied agency in a socially engaged dance context with older people with a neurodegenerative condition.

Soft skills and their development in the dance well case study

As noted at the beginning of this article, soft skills are patterns of thought, behavior and communication that help people navigate their own emotions and interpersonal relationships. Yet in the research leading up to the creation of the guidebook we found that dance artists were often not aware of their soft skills nor how to articulate them, even though they were using them in their dance practice (Empowering Dance, 2022). In revisiting Dewey (1925, p. 299) characterization of anoetic, pre-conscious knowing—"they give us our sense of rightness and wrongness, of what to select and emphasize and follow up, and what to drop, slur over and ignore"—it flags the intuitive judgement calls and behaviors that allow us to be openly present in a space with others, which also characterize the practice of using soft skills. Perhaps it is no surprise that dance artists use anoetic knowing in their practices with others, and yet cannot identify or articulate that knowing. Practicing soft skills is also to involve anoetic knowing.

So it is not surprising that soft skills have not been articulated much within dance scholarship or practice. Operating mainly on the level of embodied, anoetic knowing, soft skills have been difficult to translate into words or through analysis. It is perhaps also confusing that, as we discovered in the Empowering Dance project, soft skills overlap to form clusters, where one soft skill needs several more to be executed. Moreover, soft skills exist as the sub-layer beneath more specific technical skills that are more overtly practiced, investigated and spoken about. Despite the technical and artistic skills also being subject to anoetic knowing in dance (see above), the interest in trying to articulate these is greater; undoubtedly because they are specific to dancing and hold long traditions of debate, artistry and scholarship. Soft skills are general. They are not specific to any field and therefore do not hold the same interest to discipline-specific enquiry. Yet dancing does illuminate an important aspect of soft skills, namely that many of these soft skills come to life through embodied, sensorial action. The Empowering Dance project (2020–2023) concluded that:

"Dancing with others is an important pathway for developing soft skills, because the body plays a central role in how we navigate our emotions, responses and actions: soft skills grow through, with and embed in the body and by encountering other bodies in space" (Empowering Dance, 2022). The body is not often named in manuals of soft skills development, and yet it holds much importance for soft skill development.

I will discuss the practice of soft skills in dance to achieve a sense of embodied agency through the case study of Dance Well, as I have already mentioned. I have engaged with Dance Well in my writing before (Houston, 2019), but not in an academic paper to talk about its relation with soft skills. As I indicted earlier, the Empowering Dance project took on as a key element in the R&D process an internal reflexive dialogue with dance artist members of the group reflecting with guidance and prompts on their experiences leading, which led to discussion on the identification and articulation of soft skills. The dance artists leading Dance Well were Giovanna Garzotto and Elena Sgarbossa and a few elements stand out from their facilitation of the sessions. First the sense of warm invitation, of welcome, that every person had. This was coupled with awareness by the dance artists of the dancers' needs that day. The sense of inclusion was high. Second the use of imagery and the imagination in promoting certain qualities, dynamics of movement and motivations to move. Third the invitation to be curious about movement, time and space was taken up enthusiastically by the dancers. I will explore each element in turn in relation to how they developed soft skills in both the lead dance artists and the participating dancers.

In the Empowering Dance project, we discovered that there were some attitudes displayed by the dance artists that were modeled by the participating dancers and that led to the cultivation of soft skills within the group. We called these attitudes "enabling conditions" (Empowering Dance, 2022). In Dance Well the two most striking enabling conditions were making everyone feel welcome and creating a space where no one was judged for how little or how they moved. The welcome was enacted through words—greeting each person as they came in and finding out how they were—but also through actions, such as a hug, a clasping

of hands, a touch on the back or shoulder, blowing kisses, and through smiling. The welcome went further in that it was reiterated at moments throughout the sessions. This happened by instructions to meet the gaze of someone across the room, by greeting a person walking past in the space, or by holding hands, and by the invitation to stay afterwards in conversation. Since the first four months of the sessions occurred during lockdown periods in the COVID-19 pandemic, these were conducted online. Despite not being able to touch, the instructions were similar. The group were asked to bring their gaze, their smile, or their moving hands, close to the screen, to be in contact with their fellow dancers online.

Comments during dancing, such as "I'm tired, but I am smiling", acknowledged the reality of the fatiguing body of the Parkinson's dancer at the same time as offering an alternative happier vision through dancing; an inner smiling body. In one online session with the Schio group Garzotto invited people to find a sofa or comfortable floor space. The group were invited to create an imprint of their body where they lay and to explore what happens to the changes in way the body is organized when one puts a foot up, or an arm. In subverting the hierarchy of being upright, which is not necessarily a comfortable position always for a person with Parkinson's, the reclining aware body is celebrated as capable and reflective.

The dance artists noticed that not only did the participant dancers respond to the warmth of the welcome, they also started modeling the same welcoming behavior themselves toward others. This included in Bassano welcoming a group of young asylum seekers from North Africa to dance. Housed in a city with a far-right local government, the asylum seekers were not welcomed universally. Dance Well participant dancers did model the welcome they had received from the teachers to the young people, in voice, action and attitude. A couple of the young people eventually became integrated members of the teaching team.

Creating a welcoming, non-judgemental space enabled the soft skill of understanding and appreciating differences to be brought into focus. Also named as "respect for diversity" by Hoskins and Liu (2019), this soft skill is seen as important for active citizenship. Diversity is defined in several ways. For example, the Council for Europe's 2016 report talks of cultural diversity in its list of competencies (also known as soft skills) for living in a democratic society. It writes: "This value is based on the general belief that other cultural affiliations, cultural variability and diversity, and pluralism of perspectives, views and practices ought to be positively regarded, appreciated and cherished" (Council of Europe, 2016, p. 12). In the context of Dance Well, it is important to add in diversity as it pertains to health, bodily function and mobility. I would argue that it is also the case that this soft skill was accompanied and demonstrated by the soft skill of taking care of others.

Dance Well welcomed people with Parkinson's and those without, or with other health challenges. Individuals therefore had to negotiate encounters with others of varying movement capability and health. Additionally in welcoming young asylum seekers the group had to move with those from a different culture and political status, as well as from a different generation. Inevitably, health, cultural, ethnic and political differences are inscribed in the body, how it is perceived by the self and others, and how it is dealt with by institutions (Noland, 2009). The social marginalization of those with neurodegenerative conditions, of those without citizenship, and those of a minoritized culture or ethnic background is not to be underestimated. Embracing of bodily difference is uncommon, yet much needed for those who have to deal with judgement, prejudice and lack of institutional support.

The fact that much difference is related to the body means that dancing in relation to others and with care potentially holds a key to connecting and even fostering a sense of belonging in the face of diversity. To do this requires dancing to become a relational, people-centered activity. By this I mean that the act of moving with others in the space intentionally prioritizes connection and the purpose of the act is primarily focused on the people in the room, rather than on the technicality of the form of movement. The soft skill of understanding and appreciating difference was practiced with care in Dance Well bringing with it the outcomes of connection and a feeling of belonging.

The key outcomes of connection and belonging, were indicated in several ways and encompassed several soft skills, as well as understanding and appreciating difference. First through creative and collaborative movement tasks, for example in creating a score together to improvise around. Such tasks demand soft skills of cooperation, team work and negotiation and so also an understanding of perspective of those they negotiate and cooperate with. Second through communal decision-making, such as inviting the Dance Well dancers to commission a choreographer from Bassano's Operaestate Festival to make work on them. Such decision-making is a key artistic contribution to the festival and indicates not only critical awareness of aesthetic preferences (again a soft skill), but also membership of the artistic curation team. Third through actions and gestures that state each person is welcome here, as outlined above; and lastly through cultivating a sense of pleasure and joy in moving together. It is no co-incidence that the first research to come out of another Parkinson's dance group, Dance for PD, concluded that one of the most important aspects of dancing with Parkinson's was embracing joy (Westheimer, 2008). Similarly to Dance for PD, pleasure is evident in Dance Well through movement tasks that allow people to play, to have fun within a movement conversation, and to explore the sensuous nature of the living, sensate body outside of an everyday context where their bodies are seen as flawed. This invariably calls upon the imagination, a key ingredient of playful movement. For example, one session started up a movement conversation through the blowing of kisses to one another. This was followed, as the catalyst for movement improvisation, by the dancers imagining clouds transforming in response to the movement of their bodies. The playful, imaginative component of the classes allows the dancers to not only create their own unique ideas that give them the capacity to move with expression, but also to share those ideas with others who are responding in their own way to the same prompt. This then creates moments of movement dialogue where each imaginative idea is connected to another through embodied movement.

The creation of these pleasurable connections, as well as collaborative aesthetic decision-making, are the components that develop an environment where differences are appreciated and belonging to the group is fostered. Social justice activist and philosopher Ginwright (2022), p. 15 argues that "belonging is the capacity to see the humanity in those that are not like us and to recognize that the same elements that exist within them also exist in us". On a level of playing through and with movement,

I argue that it is possible to see humanity in those we move and play with, to make sense of and with them. For example, by taking the movement of the dancers with Parkinson's out of a context where it is pathologized and where the dancers are separated and "othered", and into a situation where the imagination inflects movement and expression, the whole person is more readily seen and recognized; particularly because each person is sharing their own response to the imaginative impulse through embodied movement. It is important to note that the sharing and recognition is reciprocal. Each dancer with Parkinson's is not merely being seen but are recognizing and appreciating others in turn. Meeting others in improvisational, imaginative movement may spark new sense-making not just for that one actor, but for all participating (Merritt, 2013). In bringing their own responses through movement, the dancers may together create new ideas and sense and become collaborating agents.

What I am also describing above could be the conditions for the development of the soft skill of empathy through dance. As Hoskins and Liu (2019) point out in their UNICEF report on life skills, empathy is a contested term spanning several disciplines. Bringing common elements together, Hoskins and Liu summarize that definitions of empathy contain both "a cognitive component of understanding the feelings of another by imagining his/her perspective and situation" and an affective dimension "in which individuals can reproduce these feeling in themselves and simultaneously realize that these feeling are not their own". They go on to explain that "as a result of these internal processes, individuals are able to sympathize and to act to support the other person" and, they add, with emotional control (Hoskins and Liu, 2019, p. 64). Dance Studies emphasizes the embodied and kinesthetic dimension to empathy, with Foster (2011), Warburton (2011), Reynolds and Reason (2012) as some of the key contributors, with accompanying neuro-scientific papers such as Calvo-Merino et al. (2008).

The generosity of the Dance Well dancers toward each other, indicates potential empathic support being given by individuals. Yet in examining the sessions the soft skill of empathy is also created within the dancing itself. Dance artist Giovanna Garzotto articulated her experience and the specific inflection of empathy within Dance Well:

> The point of empathy in a Dance Well class is not understanding but being available to experience with someone else. As a Dance Well teacher [I] experience a sense of going beyond my own body. Empathy is when the borders of my body expand and go beyond. It is a very physical experience to me. It can be recognizing that we share the same speed intensity based on a proposal or that we have reached the same level of engagement (Garzotto, in Empowering Dance, 2022).

Garzotto continues:

> It's difficult to conceptualize this experience. But there is a task that can be a good example. It's the mirroring task. It is the first improvisation task that we propose to newcomers and new groups of dancers because it triggers movement, and it breaks loneliness. But we then realize it also activates active listening, empowerment, co-leadership, and breaks the barrier between bodies even without touch. If I think back to the first years of Dance Well, we used this practice because it was the easiest one available. We then experienced through practice how many soft skills it activates, including empathy (Garzotto, in Empowering Dance, 2022).

Garzotto's experience fits appropriately into the philosophical discussion around dance and empathy. Taking cue from Bourriaud's (1998, p. 24) argument that "art is a state of encounter" and relational, the act of dancing can be seen as movement between bodies (Reynolds, 2012), which produces affective sensations in dancers and spectators alike (Thompson, 2009). Taking this as the case, the discussion around empathy in dance is primarily in relation to affect (to affect and be affected). Reynolds (2012) characterizes affect as "fluid relationality" (p. 127). It is less about connecting between discrete beings, as posed in Hoskins and Liu's summary, and more about sharing a liveness and dynamism across personal boundaries. Theater scholar Thompson (2009, p. 119) suggests that affect is a "capacity and intensity". It is an aliveness and vitality within engagement with others and importantly affect refers to "the augmentation or diminuition of a body's capacity to act, engage and to connect" (Cough and Halley, 2007, p. 2). The body's capacity to act is seen in Garzotto's examples where she describes her body going beyond its boundaries, to expand, and to attune to the experience of another, which moves her and her partner.

The mirroring task, which Garzotto describes, asks one person to follow the other's improvised movements. Each take turns to being the leader. It is a task that is also used in Dance Movement Therapy and has some investigation around its significance in inducing empathy (see for example, McGarry and Russo, 2011; Mintarsih and Azizah, 2020). Yet here it is used within an artistic context where it is the participation in an artistic generative practice that is foregrounded. Receiving and generating movement that requires active listening to "tune in" to one's partner also causes, in Garzotto's evocative words, expansion. Whilst usually related to professional dancers and to an inward focus (Batson and with Wilson, 2014) attention in this case refers to the sensory attunement to another's capacity to move. The expansion experienced through active listening (another soft skill) can change perception and perspective of both movers. Philosopher Brian Massumi explains:

> When you affect something, you are at the same time opening yourself up to being affected in turn, and in a slightly different way than you might have been the moment before. You have made a transition, however slight. You have stepped over a threshold. Affect is this passing of a threshold, seen from the point of view of the change in capacity. . . .A body is defined by what capacities it carries from step to step. What these are exactly is changing constantly. A body's ability to affect or be affected—its charge of affect—isn't something fixed (Massumi, 2015, p. 4).

The soft skill of empathy, developed in these generative, relational and cooperative movement acts points to a collective practice of gentle action and agency. For a person with Parkinson's the changing of one's capacity through affective empathy might be important, even empowering. Despite the inevitable threat of more limited movement, a Parkinson's dancer can change the capacity

to affect and be affected through dancing, not because they have Parkinson's—there is no pity involved—but because they choose to stand within a relational movement practice with others.

Now that I have pointed out how one might conceive of soft skills within a socially engaged dance practice with and for people with Parkinson's, I would like to skirt back to the discussion initiated at the beginning of this article on embodied agency and mastery of movement. What linked that part of the discussion with the outlining of soft skills in a relational dance practice is anoetic knowing. What the study of soft skills generated through a physical practice suggests is that just as the mastery of movement is embodied, so too are these relational skills, crucial to a person's engagement with others and his or her environment. In contrast to the embodied agency afforded by the mastery of movement, soft skills might be what is practiced and honed by those with little formal dance training, including those with a neurodegenerative movement disorder.

I have spoken above about the embodiment of soft skills, and their potential to change perspective. The potential to change perspective of the actor and those he or she comes into contact is, I would argue, agentic. I described Dance Well as a programme that is radical in its strategy to link various artistic and cultural institutions to the dance classes, as well as the people who live, visit and seek shelter in the city. Within the dance sessions themselves there is also an enthusiasm to give those that dance more decision-making within what and how they dance. I term this radical because for a dance programme for people with Parkinson's it unusually sets itself up not just as a tool for wellness, but as a community building and artistic development hub of dynamic movement research by those who dance there. "Movement research" is a term that Dance Well uses itself to describe the improvisational, generative exploration that happens through movement within the sessions. Generative exploration is not about standing still. Sociologist Chris Shilling's view of embodied agency is pertinent to Dance Well's social position. He argues that it is important to

> require a view of the embodied dimensions of agency that is shaped by the social system but is no mere reflection of it; that possesses a creativity able to affect the reproduction or transformation of social structures; and that is subject to change over time (Shilling, 1997, p. 748).

Similarly, Noland's (2009) definition of embodied agency cited at the beginning of this discussion stresses the power to change behavior or beliefs to react or collaborate, to resist or innovate. It is with this characterization of embodied agency in mind when I think of Dance Well's ability to create a radical proposal for movement within specific social and artistic structures and systems that do not normally engage with people with Parkinson's, or for those without citizenship. The soft skills present in Dance Well's work create the groundwork for a step away from systemic marginalization and disempowerment.

This article makes the claim in relation to Dance Well that physical, aesthetic practice with others may build sensory, affective experiences, which in turn develop qualities of care, appreciating difference, empathy, active listening, among others. These experiences are sense-making on the level of building and sharing a capacity to act and step "over a threshold" (Massumi, 2015, p. 4). It is through this shared anoetic sense-making that Dance Well dancers may transform not only their own positioning regarding their sense of capacity with Parkinson's, but also that of others who dance with them. Practicing soft skills through dancing might be an important step to embodied agency where change by dancing, through dancing and in dance happens. In Shawn Ginwright's ground-breaking book *The Four Pivots* on reimagining social justice, he argues that transformative relationships focus on what I would term soft skills and those qualities seen in dance improvisation that build up the practice of soft skills. He writes that transformative relationships

> are based in those features of life like care, vulnerability, love, curiosity, connection. Transformative relationships are formed when we exchange pieces of our humanity with each other. When we do that, we give permission to others to do the same (Ginwright, 2022, p. 115).

Dance anthropologist Grau (2013) argues that it is dance's special relationship with embodiment that makes it an effective medium for the recognition of each other's humanity and "a favorable medium for dealing with issues of social conscience", as seen in Ginwright's work in social justice. What Ginwright describes can be seen in the empathetic expansion of the body within the mirroring task, the embracing of the older woman who can no longer walk without assistance, the young woman from Ethiopia, the middle-aged man who is unsure of how he will cope with his new diagnosis of Parkinson's, the embodied sharing of imaginative proposals. The embodiment of soft skills within movement improvisations opens out the landscape of possibility for every one of the dancers and those around them and in doing so brings agency.

Future directions

To summarize, the article has drawn together two distinct areas of enquiry, that of embodied agency and soft skills within the field of community dance. My case study of people with Parkinson's dancing demonstrated how soft skills could encourage embodied agency whilst dancing. Whilst Dance Well was a concrete example, there is no prescriptive method for working with soft skills in dance for future studies and practice. Instead, there is a value system that will prioritize person-centered facilitation, a goal to set up the enabling conditions seen above to help fertilize soft skill development, and a commitment to creating movement investigation that enables participants to choose and imagine their own movement worlds. There is deliberately no prescription to developing soft skills in dance because to do so would close down different avenues of movement possibility and engagement suitable for diverse groups and different artistic practices developed by dance artists and those they work with.

In thinking about future directions for researching soft skills and embodied agency in dance, it would be interesting to consider more tangibly the notion of social justice and transformation suggested, which would need a long-term study. Another future direction would be to examine in more depth the connection between anoetic knowing and soft skill practice, as well as the

mechanism between agency and imagination. Whilst this paper has established the link between embodied agency and soft skills practice in dance, there is plenty more empirical and philosophical study that can be mined in this field.

This article has argued that practicing soft skills has huge potential in a dance context to create an environment where embodied agency is present for participants with Parkinson's, as well as for others who dance with them. Although my example was primarily focused on people with Parkinson's, the mixed group context suggests that working through soft skills in dance may positively affect any population or group, for example, teenagers, bankers, health professionals, social workers. Indeed, the Empowering Dance project went on to work through movement with social workers and teachers in Italy. Crucially, what my argument has shown is that those who have a health condition, illness or disability, who might be denied respect and dignity in everyday life, might, through the practice of soft skills dancing, develop embodied agency. It points to the importance of creating training for dance artists in recognizing soft skills they have or want to develop in their own practice. It highlights the expansive, generous nature of an art form that can accommodate soft skills practices and development for not just professionals working in the field but for the transformative potential they have for everyone on the dance floor.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Ethics statement

Ethical approval was not required for the studies involving humans because permission was given and an ethical process detailed through legal contracts to R&D collaborators drawn up by industry partners. A robust on-going ethical process and data management was managed by the lead industry partner. The case studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

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Conflict of interest

The author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Anticipation, agency and aging–conditions for making movement irresistible

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This article describes an approach to developing and maintaining interpersonal agency through guided movement and responsive technologies. Making Movement Irresistible (MMI), considered conditions for developing a digital, online and wearable intervention that could make the act of movement irresistible for older residents in care, and encourage improvisational and social interactions. Working within a co-design framework, we combined making material objects and moving together as a method of examining the efficacy of human to human, and human to technology relationships to cultivate agency. Given that movement as performance is frequently not practiced or uncomfortable, we invited a variety of experts as our co-designers to notice the nuances of movement that interested them and to document these using drawing, writing and visuals. This documentation was gathered regularly in journals as the workshops progressed, leading to a coherent capture of data as it emerged. This data allowed us to attribute value to how simple actions could become a conduit for more ambitious, exploratory interactions. Our playful methods afforded the participation of co-designers, enabling us to situate our proposed intervention within a relational and social, rather than medical model, of ageing. Making movement do-able and relational, so that it can be shared and extended with a partner or carer, informed the idea to design a wearable device that could detect movement variability, resulting in a prototype, named emitts®. The device makes use of the hand as way in to accessing whole body interaction. Our work with responsiveness of visual feedback avoided deterministic targets, as with no two movements being identical, the reported problem of compliance with repetitive tasks could be reduced. The technology foregrounded movement that was capricious and improvisational, offering new modes of artistic practice and engagement through play and performance. The case we describe highlights the importance of understanding the conditions that augment social interaction, rather than specifying design criteria for determining interaction. The longer-term health benefits of our intervention have yet to be measured, however, our collaboration has revealed how interpersonal agency emerges when we socially, aesthetically, and physiologically stimulate movement, making it irresistible where there may otherwise be resistance.

KEYWORDS

artistic methods, irresistible movement, responsive technology, sensate movement, relational agency

1 Introduction

What is it about repeated movement for the purpose of exercise, rehabilitation and "what the physio says," that is unmotivating and, over time, an uphill struggle? It seems that approaching movement as exercise risks instrumentalising it and removing the potential agency residing in movement itself. Typically, carefully instructed movements may become medication-like, universal, problem-solving, and outcome-focused. And as we get older, we are increasingly encouraged to move with the basic rationale of improving our health through a programme of movements. Yet, within movement there is a potential of it being much more, and our explorations here promote a novel lens in a reframing of movement.

Making Movement Irresistible (MMI) proposes that we can approach movement as a creative and artistic material that may shape a social role: a material that can be performed together with or in relation to others. In reframing movement from exercise to a socially engaged playful relation, MMI sets out to create conditions for instigating and sustaining movement for older people in care homes–rather than relying on movements being specified and instructed. Our question concerns how we might encourage a process of discovery of one's own movement and to try something new, overcoming insecurity and encouraging play and presence. In trying to answer this, the project took inspiration from artistic practices such as dance improvisation, dance scores and somatic practices (Noland, 2009; Burrows, 2010) as well as community arts and co-creation methods (Matarasso, 2019). Such practices acknowledge that movement and improvisation require "a type of cognition anchored in the body and situated in the relation with [dance] partners and space" (Ribeiro and Fonseca,

TABLE 1 Overview of workshops, objectives, participants, materials and activities with references to further workshop documentation.

Date	Objectives	Participants	Materials	Activities	Reference
Workshop One 26/04/2022 Duration 5 h	1. Who are we designing with/for? 2. What could make movement irresistible? 3. What are the barriers to engagement? 4. What opportunities are emerging?	12 primary care providers; dance artist, occupational therapist, physiotherapist, arts and health coordinator and NHS IT manager. 10 academic, technology and design staff	Socks, haberdashery, flip chart, crayons, markers, sticky dots, screen, projector, exercise books	Welcome and ethics consent and information Playful warm-up and creating sock puppets. Movement, sensation and participation activity. Personas, dot poll, innovation exhibition, wearable and biotech presentation	https://makingmovementirresistible.org/case-study-one/
Workshop Two 22/06/2022 Duration 5 h	1. What can technology add? 2. Could technology make movement irresistible? 3. What are the barriers to using tech? 4. What opportunities are emerging?	12 primary care providers; dance artist, occupational therapist, physiotherapist, arts and health coordinator and NHS IT manager. 10 academic, technology and design staff	Socks, haberdashery, flip chart, crayons, markers, microprocessors, light assets, screen, projector, exercise books	Making movement with puppets. Experiments with adding technology assets. Exercises with digital mirroring. Show and share of insights	https://makingmovementirresistible.org/case-study-two/
Workshop Three 03/11/2022 Duration 5 h	1. What movement do we desire? 2. How could we digitally respond to movement. 3. How do we make the whole experience irresistible and for whom?	9 primary care providers; dance artist, occupational therapist, physiotherapist, arts and health coordinator and NHS IT manager. 5 academic, technology and design staff	Low fidelity prototypes, box, card, haberdashery, flip chart, crayons, markers, microprocessors, light assets, screen, projector, exercise books	Group activity: Making prototype experiences such as day in the life, journey map and storytelling. Show and share of insights	https://makingmovementirresistible.org/case-study-three/
Workshop Four 18/01/2023 Duration 5 h	1. How do we provide meaningful interactions between facilitator/partner and older person? 2. What data will facilitators need? 3. How do we encourage sustained engagement?	7 primary care providers; dance artist, occupational therapist, physiotherapist, arts and health coordinator and NHS IT manager. 5 academic, technology and design staff	Medium fidelity wearable prototypes, flip chart, crayons, markers, screen, projector, exercise books	Group activity: Designing the looks and feel. Ease of use and engagements before use. What may make this movement engagement different and engage health practitioners? Online and in person	https://makingmovementirresistible.org/case-study-four/s
Workshop Five 02/05/2023 Duration 5 h	1. Who are we designing with/for? 2. What could make movement irresistible? 3. What are the barriers to engagement? 4. What opportunities are emerging?	8 primary care providers; dance artist, occupational therapist, physiotherapist, arts and health coordinator and NHS IT manager. 7 academic, technology and design staff	Medium fidelity wearable prototypes, flip chart, crayons, markers, screen, projector, exercise books	New personas and people mapping. Can-do movements. Digital Playtime. Journey mapping. Concept of emits ® consolidated	https://wahwn.cymru/knowledge-bank/-making-movement-irresistible-mmi

2011, p. 72). The use of artistic and improvisatory methods embraces a creative and participatory approach connected with individual transformation (Hanna, 2020). Our workshops involved a range of care provider experts in co-creative and explorative exercises over the course of a year where each workshop explored how to build on, and with, materials and relations by way of movement (see Table 1).

During the workshops our physiotherapy and occupational therapy partners reported that they face a significant challenge with patient adherence to a prescribed exercise programme. They advised us that despite being given instructions on how to perform their prescribed movements, older people were frequently unmotivated to practise the recommended exercises. Research indicates that adherence is influenced by low baseline levels of physical activity, poor self-efficacy, depression, anxiety, helplessness, poor social support, greater number of perceived barriers to exercise and increased pain levels during exercise (Kåringen et al., 2011; Rowsell et al., 2022; Room et al., 2023). Older people are particularly at risk of low adherence and are likely to have multiple and long-term conditions for which prescribed exercise is a treatment option (Room et al., 2017). Addressing this gap in behaviour, we foregrounded movement as material with which we could connect the mover, carer and technology through certain conditions and by addressing the agency in movement itself.

The range and severity of movement impairments in older people needs a broader, relational (peer-to-peer), less diagnostic and more motivational approach to exercise (Peek et al., 2016). Findings from our initial research indicated a need for imaginative techniques that can offer choice and agency within exercise routines. For example, using metaphors such as "move your arm like a swan" rather than an instruction for lifting your arm (Butt, 2017, p. 343). Recent research shows that dementia is not a hindrance for explorative learning (Ingebrand, 2023). What MMI has aimed to do is to explore movement beyond its everyday function, by cultivating aesthetic capabilities.

2 Artistic, sensate, and aesthetic practices

Improvisation is a form of creative practice whereby a set of rules or parameters may frame new movements and meanings (Burrows, 2010) and thus invites a person or performer to be in contact with their individual aesthetic sensibilities. These sensibilities are tied to perception, which is at the core of exploration, learning and creative imagination; as we improvise the moment, we cease to know what is going to happen (Tuffnell & Crickmay, 1993). For movement, the felt experience of moving–kinaesthesia: "allows us to correct recursively, refine, and experiment with the practices we have learned" (Noland, 2009, p. 4). In improvisation the interaction itself "gives us access to the intentions and emotions of the other as well as to a field of shared interactively created meaning" (Kronsted and Gallagher, 2021., p 39).

We approached the research project from the premise that sparking the imagination was key for engagement, and consequently sought to probe these aesthetic sensibilities in greater depth, seeking what may be identified as a flow state where movement is "a self-justifying experience; it is, by definition, an end in itself" (Csikszentmihalyi, 2014, p. 250). From our previous research we have learned to value the perceptual qualities of sensation, attention, repetition, feedback, feedforward, and connection, as conditions that may be harnessed in a design concept (Hansen et al., 2017; Wilson, 2017; Sumner et al., 2019; Keay-Bright et al., 2021). Typically, these aesthetic and kinaesthetic experiences are ephemeral and intangible. However, the impact of bringing these elements into consciousness is known to improve agency (Reynolds and Reason, 2012) and improve kinaesthetic empathy - that is the access to the perception of one's own or others another's kinaesthetic experience (Parviainen, 2003).

2.1 Anticipation and immediacy

Whilst words may take time to access and compose, the moving body affords a gestural immediacy, expressing a multitude of meanings that may be implicitly understood (Tversky, 2019). Yet even with the immediacy of instruction and presence of mind, there is evidence to suggest that a period to prepare, and to stimulate ahead of moving "may be beneficial in preparing for movement readiness and thus result in better motor execution by the patient, and hence better rehabilitation results" (Crasta et al., 2018, p. 111). As the aim was to encourage movement, we understood that the relation and preparation and context of an exercise or an engagement is central in how it is to be performed. This can, in part, be described as entrainment: "a spatiotemporal coordination resulting from rhythmic responsiveness to a perceived rhythmic signal" (McNeill, 1995, p. 3) and can be valued as a social practice (Phillips-Silver et al., 2010) that may be developed and refined (Phillips-Silver and Keller, 2012). It has been found that an injured brain can indeed access rhythmic entrainment mechanisms (Crasta et al., 2018). Research in entrainment points to the foundations for how people typically engage in a reciprocal manner: "as we converse, we increasingly use each other's words and gestures" (Tversky, 2019, p. 111) and in people, coordination quickly turns into cooperation (Ibid).

2.2 Guided movements as a mode of engagement

Guided movement suggests that movements created in relationship with another person, as in empathetic facilitation, invite interaction where sociality and connection provide purpose and motivation (Christensen et al., 2021). To support an understanding of movement in care home contexts, dance improvisatory practices such as those introduced by post-modern dancers in the US and the UK in the 1970s provide a useful reference point (Mackrell, 1992). Whilst an improvised dance performance event may be scaffolded by a "score", a set of rules or parameters which frame an improvisation (Burrows, 2010), the movement content also unfolds as dancers respond moment by moment to each other's dancing bodies and other stimuli. Works are not set, and the dance vocabulary is not usually predetermined: "For each moment in improvisation, the dancer reacts to her own current kinesthetic unfolding in order to make the next movement" (Kronsted and Gallagher, 2021, p 41). The principles behind

contact improvisation are also relevant here, in that this is a partner dance which progresses by attending to your partner through points of physical contact and weight sharing and acting on one's own pull of gravity (Paxton, 1975). Moving away from theatre dance, principles that guide community dance practice are helpful in defining an ethical basis for dance interactions with non-professional dancers (People Dancing, 2024). In this approach, the movement is created through the perception and relations to others, which, in turn, creates a renewed sense of self. Research has shown that intersubjective relations are key in dance-health practice "in enabling the dance artists, acting as guides, to facilitate a heightened awareness of somatic and subjective lived body experience" (Hanna, 2020, p. ii).

2.3 Designing engagements

Aesthetically-led processes can bolster engagement in the crafting, shaping and making of materials towards a design - whether an object, event or practice (Hallnäs, 2011). Movement as creative and artistic material challenges the notion that materiality is only physical. Movement is performed by our physical bodies and manifested in every instance, yet it is this temporality that also means that it is forever disappearing (Phelan, 2003). This ephemeral aspect of movement is essential for how we typically see and handle movement. Still, we also have an experience of the lasting effect a movement can have - from a moment or over time (Hansen and Lyster, 2023). When we focus on movement as a creative, aesthetic material, it has implications for the understanding of aesthetics. In interaction design, aesthetics has moved its focus from appearance to interaction (Djajadiningrat et al., 2000), recognising our perception of aesthetics in any one moment as dynamic and changeable. Theories for interaction aesthetics focus on its temporal nature, whereby concepts such as pliability, rhythm, dramaturgical structure, and fluency play an important role in conceptualising aesthetics (Lowgren, 2009, p. 5). In art, the concept of Relational Aesthetics (Bourriaud, 1998) summarises this changed view on aesthetics, with an emphasis on the temporal and interpersonal interaction, which happens in between people when the stage is set. The physical, static form of the work itself - the stage - is of less importance. It is the situation that is created and what that does (its performative potential) rather than what it is (the staging) that becomes interesting.

2.4 Exploring technology through dynamic, sensory engagement

In dance improvisation the perception of movement is shaped by "an ongoing cycle of acting on affordances and being acted upon. Each movement brings out new possibilities that the dancer must engage to keep the participatory sensemaking activity going" (Kronsted and Gallagher, 2021, p.43). Making use of this dynamic opens up a possibility to leverage individual agency and relational movement, as it frames how a perception of movement may continuously be interpreted in relation to its preceding movement.

The benefit of a wearable device is that sensors providing feedback may be designed to provide a unique focus on detecting and responding to particular movements (Keay-Bright, 2011), thus feeding into an entrainment practice–a relational synchronisation of new movements. With age there is typically a physical reduction of movement possibilities, yet Jung has shown that directed self-awareness may expand the scope of personal data through the use of mobile and wearable applications that draw attention to how people may "notice, express, question, and respond to their felt senses" (Jung, 2023, p.30). Phillips-Silver et al. propose that for entrainment to emerge, three central aspects are required: "to perceive stimuli as rhythmic, to produce periodic stimuli, and to integrate the two using sensory feedback" (2010, p. 10). There is a need to order and amplify the feedback from movement and that the feedback should be direct, clear and playful (Keay-Bright et al., 2021), for example, using a range of light effects that can draw attention to, and enhance visual feedback by exaggerating aspects of the movement itself (Hansen et al., 2017).

In dance and dance improvisation dancers and instructors often work with mental images to get the right kind and quality of movement, which could be prompts such as "imagine moving in honey" (Christensen et al., 2021, p. 17). A focus on the materialising of feedback in an aesthetic manner was a central feature in this project, and a variety of feedback modes were explored–such as sound, light, colour, line, and shape.

Houston and Gillette (2022) offer a map of soft skills that surround effective practice when leading dance in a community context, which includes empathy, dealing with uncertainty, cooperation, taking care of others, flexibility and adaptability, managing information, patience and appreciating difference. They suggest that these skills "encourage individual and personal approaches to working relations and social encounters" (Houston and Gillette, 2022, na).

These soft skills were explored during our workshops, beginning with a mode of dance improvisation that offered inexperienced dancers the same starting point as more confident dance practitioners (see Figure 1). Using movement to build connection with another person requires willingness. Openness, curiosity and creativity, and the suspension of judgement of self and others, which was vital in this arts-informed project.

As action moulds perception (Tversky, 2019), all actions may, in turn, enable new actions, if reframed as a source of engagement or possible relation. The motivation to move then, may be reframed in the form of experimental movement, imagination and play in relationship with another person and enhanced through responsive technology. Seeing movement as the unfolding of one movement into another, and as a self-justifying experience, may assist this entrainment of the senses. Our experiments with camera-projector-screen-based responsive technology, further enabled us to explore a digital materialisation of movement that in turn, enabled play - as immediate and visceral.

3 Materials and methods

The Making Movement Irresistible project required the academic and practical study of movement from a wide range of disciplinary perspectives and brought together an academic team with expertise in biometric science, stroke and dementia research, interactive and material arts, dance and music technology. Our

FIGURE 1
(A) Exploring movement beyond its everyday function through cultivating playful social interactions. **(B)**: Sensory attention to touch and relationship allows movement to emerge organically in an unfolding "conversation." **(C)**: using mirroring to prompt moving together and to overcome uncertainty.

FIGURE 2
(A, B) Participants' exercise books forming an essential part of qualitative data collection. **(C)**: Exercise where a web of ribbon re-defines the space as a playground for imaginative movement responses, whereby the situation is created and what that does, becomes an interesting outcome. **(D)**: Adding "light" as a sensory component to a sock-puppet using simple electronics.

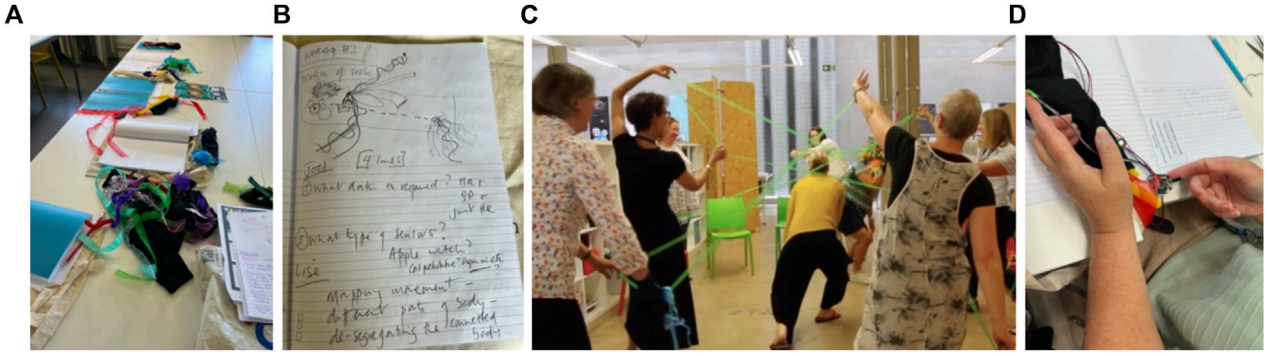

FIGURE 3
(A, B) Participants' exercise books forming an essential part of qualitative data collection. **(C)**: Exercise where a web of ribbon re-defines the space as a playground for imaginative movement responses, whereby the situation is created and what that does, becomes an interesting outcome. **(D)**: Adding "light" as a sensory component to a sock-puppet using simple electronics.

participants were experts from clinical practice and arts intervention, including dance artists/practitioners, occupational health and physiotherapists and a range of activity providers working in the care sector. This partnership has been achieved through the known networks of the academic team, whose research prioritises participatory and inclusive methods within iterative

FIGURE 4
(A) Journey mapping exercise of conditions that connect us to our moving bodies such as people, settings, aesthetic materials and playful movement invitations. **(B)**: Exploring a low-fidelity prototype to see amplification of movement contributions through aesthetically pleasing digital feedback (such as sound, colour, light, line and shape). **(C)**: Acting out inter-personal agency as social, empathic and aesthetic movement interactions.

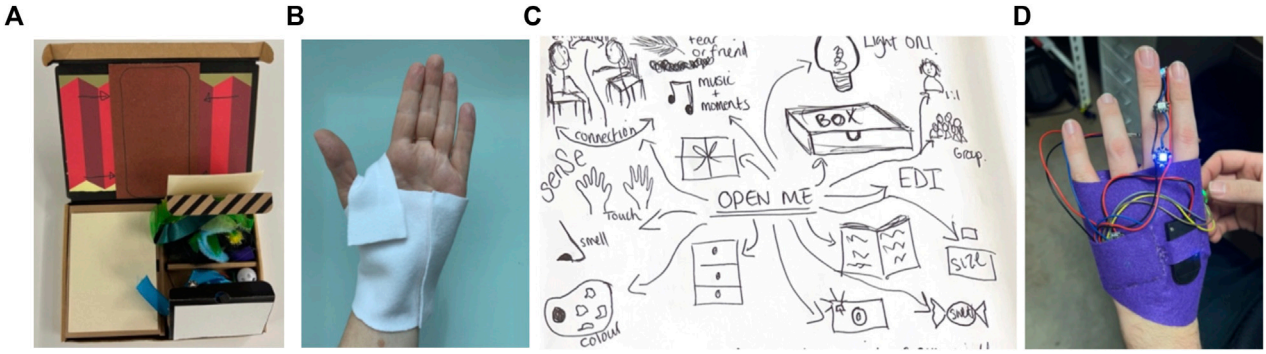

FIGURE 5
(A, B) Medium fidelity prototype of a presentation box containing a wearable mitt with optional sensory accessories. **(C)**: Relationship Map showing how the "mitt" might reach the intended users. **(D)**: Medium fidelity prototype "mitt" linking lights to motion sensors where lights turn on and off in response to the tip and tilt of the hand.

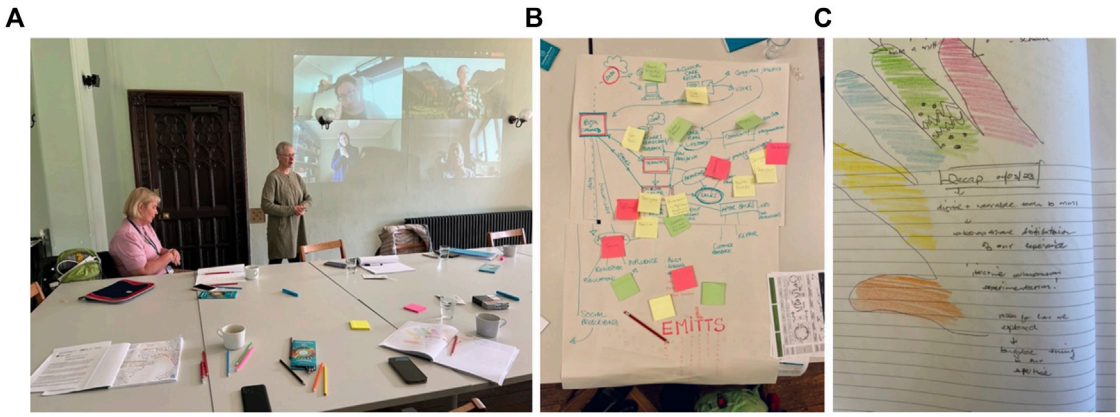

FIGURE 6
(A) Participants both online and at Insole Court being guided through a sensory mapping of their hands. **(B. C)**: participants' diagrams of stages required to introduce emitts® into a potential care environment.

cycles of design and implementation. The team has significant practical experience of including people with a range of age-related disabilities, such as stroke, dementia and complex needs, in research and a track record for creating evidence-based interventions that develop self-efficacy through human-to-human interaction and technology (e.g., Adams et al., 2015; Hansen et al., 2017; Wilson, 2017; Sumner et al., 2019; Buckley et al., 2020; Treadaway et al., 2020; Keay-Bright et al., 2021).

Our method for involving arts and health partners as collaborators in envisioning a movement intervention was a series of five co-design workshops that ran over a period of 1 year. The workshops were structured around five core questions: who, what, why, where, and when and together the workshops addressed the overarching question, "what makes movement irresistible?" Posed as questions, these five workshops enabled us to examine the conditions that connect us to our moving bodies, for example, the people, materials, activities, settings, and participatory infrastructures that may affect the desire to move. Three workshops were hosted at a local conference venue, a Victorian listed building with gardens, and two were held at the university design studios. Participants who were unable to travel joined online. Whilst this was challenging at first, as the community of participants became more familiar with one another, we started to design the workshops with online activity as a feature rather than an alternative.

3.1 Research design

In addition to the core questions that pertained to the conditions that make movement irresistible, the workshops also explored how movement could contribute to co-design. For example, how making physical artefacts and performing everyday actions - such as mirroring and waving–could, gently and inconspicuously, prompt moving together. The ease of this activity supported an experience of designing that became increasingly creative. The aim was to investigate whether participants felt a sense of belonging and agency when the sensation of movement was brought into consciousness. Such an approach was valuable, as we were interested in tapping into the kinaesthetic and empathic potential of movement. In each workshop participants took notes in individual exercise books. Exercises, discussions and presentations were filmed. The principal researcher summarised the resulting material from each workshop. This was sent out to all participants to enable the planning of next steps, and informed the iterative, qualitive thematic analysis driving the development forward.

As the workshops progressed toward the "where," relationships became the most vital condition for making movement irresistible. However, as none of our workshops were held in a care home due to the pressures on staff, the project invited professionals who would normally deliver activities in care homes to participate in a dedicated workshop space. Here, they shared the experience of working with older people, who had had a lifetime of being with others and who now relied on staff, each other, and visitors for company. Moving together was described as a key motivator for engagement (Houston, 2019). The intention was to shift movement from being instrumentalised and normative, and to optimise moving as empathic, social and creative. The kinaesthetic and empathic potential of movement was an important factor in the preparation of the aesthetic aspects of workshop activities, such as using fabric and feathers, and including new sensorially interesting materials as we developed prototypes. This materialisation was designed to allow for a directness, clarity and playfulness of feedback, whether it was a signalling hand or digital visuals and the anticipation of new feedback.

4 Summary of workshops

The first workshop posed the questions: who are we designing for, and what might make movement irresistible for this audience? As an introduction to the project, to each other and the sensation of movement participants were given a range of haberdashery materials and a plain black sock, from which they were invited to create a puppet. When worn on the hand, the puppet fulfilled the role of "alter-ego" and prompted people to meet, greet and move together in response to gentle, guided suggestions given by the experienced dance practitioner from the academic team. Beginning with gentle hand movements, we were able to gradually explore the liminal space between the anticipation of moving and the curiosity that sparks more conscious, playful and intentional action. Actions and gestures change thought, both those we perform ourselves and those we see in others (Tversky, 2019). In particular, hands have agency in how they can make up gestures through an "immediacy, precision, and congruence of their meanings." (Tversky and Jamalian, 2021, p. 772). Our exercises played with this idea of the hand as a gateway for connection to others as well as a connection to moving the rest of one's body (see Figure 2).

As participants became more relaxed with each other, we introduced camera-based digital mirroring opportunities using software created for an earlier project (Keay-Bright, 2011; Keay-Bright, 2014; Kontogeorgakopoulos, Weschler, Keay-Bright, 2014) and some face-to-face mirroring experiments with hand gestures. Participants also created simple personas, which sparked a discussion on the value of relationships rather than diagnostic representations of individuals.

Workshop two posed the question: what could we be creating? The objective was to scope the technological, artistic and biometric potential of MMI in relation to the findings from workshop one. The workshop consisted of four activities: 1. Making movement, 2. Digital movement, 3. Making more movement and 4. Moving on.

Participants were given a range of light generating electronic assets that could be hand sewn into the sock puppets. This provided an opportunity to observe whether electronic feedback could feel playful and irresistible - or if it would induce fear and rejection. As a creative tool, the electronics engendered a myriad of ideas for improving manual dexterity and functionality, demonstrating a fine line between generating movement drills and expressive, improvisatory actions. Unsurprisingly, the potential to capture, log and visualise heart rate variability as a non-invasive feature of interaction met with interest from health professionals. More significant was the idea that visually arresting heart-rate data could be a prompt for improvisatory movement, whereby both health and creative objectives could coincide (see Figure 3).

The third workshop introduced early concepts for making movement irresistible as a more holistic experience. A key question at this stage was what are we offering and how do we

encourage people to engage? An important finding from workshop two was the need to fully understand each of the stages that contribute to making moving irresistible - from the anticipation of moving, through to the curiosity induced by movement sensations, to the agency of being able to experience movement as communicative and creative in partnership with another mover. Working with a paper prototype concept for a customisable, wearable mitt with electronic assets and screen-based feedback, participants were invited, in three teams, to build three different scenarios and sketch out the stages of interaction. Using the prototype as a prop to generate stories, each team acted out scenarios for how the concept could be implemented and explored within a variety of practice situations (see Figure 4).

The fourth workshop focused on sites and timelines, taking the idea of implementation as a cue for further experimentation, plus a relationship map which identified who would be responsible for ensuring the concept reached the intended users (beneficiaries). The question of aesthetics was foregrounded in the discussion as a range of visual effects were offered. Ideas emerging from light-response interactions prompted experiments on the theme of bioluminescence, which was proposed as an opportunity to create iconic, visually coherent feedback sensations. A more refined version of the prototype was presented, which, although crude in the visual aesthetic, became a tool for envisioning how the hand and mitt could generate bioluminescent effects (see Figure 5).

The fifth workshop revisited the questions of: who, what, why, where, and when, in relation to what we had discovered about, "what makes movement irresistible". A short film was shown, capturing key movement moments and conversations from the previous workshops. Participants were invited to reflect on what had changed in their thinking on each of the questions and asked to add anything new that came to mind. A more refined prototype was then demonstrated, and participants were given time to play and make further suggestions on implementation. In three teams, the participants created large maps and flow diagrams, capturing the stages required to introduce such a technology into a care environment (see Figure 6).

5 Resulting discussions

The Making Movement Irresistible arts, health and technology project described above, has given us leverage to explore what it means to move in conversation with another person. Through our workshops, ideas emerged that prompted us to take note of the nuances of these conversations as we forged new relationships with our partners. Over the course of the five workshops, we were able to become more attuned to the conditions for initiating and maintaining relational movement. The various conditions we have noticed and explored over the workshop have taught us about i) creating engagements, ii) movement for engagement and iii) movement for relational agency. A discussion of these and the role of the technologies follows in the sections below.

5.1 Creating engagements

The invitation to engage in creative and expressive movement can be met with uncertainty, discomfort and resistance. The predominant concept of dance also implies a required level of physical and cognitive skill, as a further barrier to engagement. Making and moving with prototypes can divert attention away from the pressure to perform and attune people to engage with the sensate aspects of moving.

5.1.1 Materialising props

The workshops identified the need for a tangible, intimate, observable and shareable device for accessing the proprioceptive sensation of movement, and halfway through the workshops, a prototype wearable mitt was created. The mitt became a materialisation of the hand as a gateway to communication; simple waving exercises, tapping, clenching and other "everyday" movements could become an interesting means to explore larger bodily connections, and as a starting point for further movement. By acknowledging that movement is relational, it was important to include the developing prototype in movement explorations as a 'partner' which could shift, shape, alter and augment a movement conversation between people. Compliance could be facilitated by the attention of a partner through mutual explorations of performed movements that are enhanced and detailed by way of engaging wearable technology.

5.1.2 Encountering uncertainty and discomfort

Creating conditions for movement to emerge includes gaining motivation and confidence, whilst building the capacity for movement within the mover. In this way, personal movement practice and agency are closely interlinked. The aim is to develop and support an embodied agency - a person's possibilities and capacities for action and expression. We used qualitative thematic analysis (Cresswell and Poth, 2016) whereby reflections and participant data from each of the workshops led us to focus on the hand as a gateway to movement interactions. The hand is vital for gesture and, "just as the actions of our hands are tools that alter the world, the actions of our hands are tools that alter minds, our own and those of others" (Tverksy and Jamalian, 2021, p. 772).

Exploring improvised creative movement can initially create feelings of discomfort, uncertainty and self-consciousness. This is something participants in the workshop expressed. Yet, the process of overcoming this discomfort also leaves you with a feeling of having learnt something new about yourself. This challenge was explored precisely by introducing artistic processes to participants who were not artists. Providing an enjoyable experience may in itself reduce agitation, increase sociability and promote interaction (Christensen et al., 2021). Absorption in a pleasant activity may then reduce experiences of failure and frustration in both "'patient" and therapist if the prescribed exercises could evoke aesthetically motivated sensations.

Such thresholds and learning steps are found in trying out new practices. New practices demand uncomfortable learning thresholds. Tolerance of these experiences varies from person to person. Workshops engaging our senses in new ways are challenging. These methods allowed us to uncover what could be problematic and what could be gainfully explored further together. When facing older age and needing to expand or recover a movement range, we must look at the "unconscious patterning, unexamined inhibition, and corporeal reservations that are only apparent when challenged by new kinaesthetics" (Downey, 2010, p. S27).

5.1.3 Flow and agency

Pleasurable experiences of movement flow facilitated through a shared MMI interaction may support persistence to overcome feelings of uncertainty and discomfort. What we learned throughout the workshops relates to trust and agency, and the value of revisiting reflections and insights learned: "gaining bodily skills requires more than 'knowledge," involving changes in physiology, perception, comportment, and behaviour patterns in unsystematic, diverse modes' (Downey, 2010, p. S22). Experiments with visual feedback on mobile devices were used to capture and replay movement as a simple graphic form, explorations of space and temporality were introduced using connecting ribbons and hand clapping games. Together these activities initiated new sensations, new reactions, responses and perceptions.

This technology, however, was introduced, staged, played out and performed in a social setting–with others, whether as carers, therapists, experts, or "audience," as movement is always perceived and performed in relation to its context. Kendon has also pointed out that for signs "to be transmitted, they must be seen" (Kendon, 1995, p. 116). Over the course of the workshops, we expanded our focus from a low-fidelity prototype towards the possibility of both a wearable mitt and screen-based interactive technology. We found that the role of the facilitator became crucial over time, and the prototype could become part of this relationship. This allowed workshop participants to anticipate an interaction, and consequently have the agency to influence a triadic relation (older person-partner-technology) where shared movement creates a space of possibility.

When seeking to understand such conditions leading to an irresistibility of movement, the phenomenological experience of "flow" is worthy of attention. Sustaining one's effort in continuing to move was part of the challenge identified: "The creation of specialist bodily knowledge occurs through the ability to sense and enact shifts in temporalities and spatialities" (Carter et al., 2022, p. 248). Flow is characterised by attention to the activity which brackets out other distractions to the extent that people report a sense of agency as actions and awareness merge and perception of time is altered (Csikszentmihalyi, 2014). During the workshops we experimented with several exercises that encouraged participants to move and play individually. As their confidence and subsequently, their ideas developed, participants created a variety of scenarios, which they acted out using role-play to tease out the relationship between staff, therapists, families and older people. An example scenario was using the mitt prototype to engage a stroke patient, in which a dancer used feathers, colours and touch to draw attention to sensations and to find ways to make it easy to move together. The potential for creating experiences of "shared flow" as an outcome of an MMI interaction is a tantalising possibility.

5.2 Movement as engagement

We found that agency of movement required an understanding of the physical space, giving permission and attention, and allowing for sensate feedback in play.

5.2.1 A temporal, physical taking of space

Reframing space as creative and performative, for example, for dance, makes for a liminal space just beyond the everyday. Schechner (2017) takes an ethnographic perspective on such performative events, suggesting seven functions: a vehicle for fostering community; marking or changing identity; creating something beautiful; as performance; to heal, entertain and to persuade. In a private space witnessed only by yourself and your dancing partner, Schechner's characterisations of functional performance may be useful, giving licence to play, subverting restricting social conventions and resisting a regression to "normalcy" in support of relationship building and acceptance of difference. In a care home context, dedicated time for one-to-one interactions can be difficult, however making opportunities for your personal space to be reframed to your "stage" affords a temporal, physical and aesthetic environment where you may perform to the limits of your available space.

5.2.2 Permission to perform

Permission to express yourself can be seen as an outcome of being given attention and active listening. Research on the value of active listening in medical consultations shows a potential therapeutic value of affective physician-patient communication and positive relationship building (Fassaert et al., 2007). Fassaert et al. identify features of active listening, many of which are reliant on non-verbal communication such as an open and interested attitude, giving full attention and not being distracted, being relaxed, giving time and including comfortable pauses. Parallels can be drawn between the use of active listening in medical consultations with doctors and the attention required in dance improvisation.

Non-verbal understanding is communicated through gestures, facial expressions, eye contact, occasional physical contact and the use of paralinguistic cues, that is, communication beyond linguistics and language. In its ambition to make movement irresistible, this project explored an approach to developing meaningful movement that expands on health motivation and cognitive abilities. Our findings point to the complexities in understanding how people in care homes may choose or know to move, or the immense challenges when one cannot move as one wishes. Finding ways to cope (Noland, 2009) is important and being given a space and ways to accept, face and explore challenges are vital, and as we found, part of the conditions for initiating meaningful movement.

5.2.3 Attention to joy

When a facilitator, such as a physiotherapist or a dancer, expresses curiosity they can act as a magnet for joint exploration of movement. The choreographer Burrows suggests that in dance improvisation "even a little is enough. Are you enjoying it? It should not be a chore" (2010, p. 54). By providing a focus on sensations and gentle movement possibilities with the hands, however small, it may lead to an unfolding movement "conversation". Events or structures within such a conversation may include copy, contrast, call and response, touch, or with some people hand-over-hand supported movement. Through the hands as a point of contact the facilitator can "listen" and respond to their partner. An additional use of props and curious prompts which offer texture, colour, shape, sound or light, for example, can provoke a movement response and joyful joint exploration within a multi-sensory experience: "Understanding the senses in an ecological manner means ensuring the connections between a body and its environs, the body-in-the-world affirmed *via*

sensory interactions and the information generated, remains embedded in the contexts in which sensory information is produced" (Carter et al., 2022, p. 242). Using material can also ease inhibition through deflecting attention from oneself to the object of curiosity. In our workshops, participants who were self-conscious of moving creatively found that the use of a personalised "sock puppet" eased them into a creative frame of mind and freed them to move with less inhibition. Making the puppets into individual characters also facilitated socialisation through play. With loss of inhibition, the movement range and complexity increased. Some people then chose to discard the puppet for reasons of greater freedom in movement and a more immediate "me to you" relationship without mediation.

Houston and Gillette (2022) recognise that a positive experience of joint creativity and joyful interaction allows us to build awareness of each other and to see each other differently. This, in itself, can be transformative. We found that framing movement as irresistible and magical, new and worthwhile, allowed us to identify the conditions necessary to initiate, draw attention to, and sustain movement, however small and however self-referential. It allowed for an anarchic space to celebrate deviation particularly for those people with cognitive differences or dementia.

5.3 Movement for relational agency

We found that giving or sharing the agency over new and sustained movements was part of fostering a positive relationship between partners and it is vital to be offered the motivation and curiosity to engage with one's own movements in conversation with others.

5.3.1 A shared agency in moving anew

For people living with dementia or sensory loss in a care context in Wales, UK, there is a commitment to offering "the right for your care to be delivered in a positive and caring way and staff should take time to get to know you" (Herklots, 2022). Anticipation of a rewarding and fulfilling encounter in which you feel valued, seen and to which you can contribute in a way that is meaningful to you, is predicated on a relationship of trust and respect. Our workshops drew attention to the need to design for care and activity providers who were not dance practitioners, they may even be a relation, friend or other health professional. A sense of achievement can be supported by the facilitator if they are attuned to the individual and able to modulate the demands of the interaction: too challenging and they disengage, too easy and they get bored and distracted.

Preston-Dunlop attests that the dance and the dancer are indistinguishable where "dancing is feeling-thinking-sensing-doing with imagination" (1998, p. 55). Attention to the qualities of movement promotes an attention to aesthetics: "in dancing with aesthetic attitude you focus on the attributes of the thing you are making, on the form and rhythm of the movement you are creating, on the relationships in space and time that your movement gives rise to" (Preston-Dunlop, 1998, p. 41). The movement exercises tried out in the workshops could be seen as similar to those experienced in functional everyday activities or rehabilitation exercises. What makes the movement unfamiliar and therefore curious is its relocation as a shared aesthetic experience.

Although it takes time to internalise and embody cultural practices (Mauss, 1973) our bodies are continuously changing and adapting - even within a limited age framing. Teixeira et al. (2021) describe how older people may be able to handle and engage with technology. However, in our view, technology is not the facilitator of the interaction, it is a partner in a creative conversation, much as the sock puppet became a conduit for a performative partnership for codesign participants. It can be liberating to interact with technology, as 'nobody' is watching or judging. When moving with the mitt, we found an opportunity for joint attention, and the beginnings of shared empathy as partners acted and reacted to each other.

5.3.2 Designing for authenticity

Houston (2017) defines agency within inclusive dance as "a degree of self-determination of events by individuals that gives them the power to interact with and to act upon events positively". Authentic, shared communication is central to experiencing agency as it allows us to express our social, physical, practical needs. This approach to developing autonomy within a shared space is at the heart of interventions such as Intensive Interaction (Nind and Hewett, 2012). As a social communication approach, Intensive Interaction has improved outcomes for young people in educational and care contexts with severe learning disabilities and autism. Although not "outcome driven," intense positive reinforcement allows agency to arise as an intrinsic process of meaningful engagement. Our experiments with camera-projector-screen-based responsive technology, enabled us to materialise the flow of movement in digital form, which, in turn, enabled play - as immediate and visceral. The combined experience of positive feedback and the curiosity to discover more of one's potential to create magic affords a similar intensity, as each movement stimulates the next. The partner's role in the interaction is less about correcting and more about promoting a continuous somatic reflection-in-action as a duet. Over repeated interactions, a repertoire of movements can be developed and enjoyed. This may occur through instigating movement or indeed through the rejection or acceptance of an improvisation opener offered by a facilitator. Jung recognises such improvisation as an intentional component of a design brief: "Reflection through focusing on felt senses has been shown to lead to alternative design propositions and to induce self-knowledge beyond tracking past actions" (Jung, 2023, p. 15). Designing authentic movement interventions will require more uncertainty, more involvement, and more variation, yet such a development may also provide real value in enjoying movement and living well.

6 Conclusion

The transdisciplinary group of partners who engaged in researching and co-designing Making Movement Irresistible came together to develop a greater understanding of how to engage and experiment with movement, framed as an explorative study funded by the Arts Council of Wales and Cwn Taf Morganwg University Regional Partnership Board. These experienced professionals worked together to offer a novel lens for reframing movement of older people in care home settings.

Through this collaboration the project brought particular aesthetic aspects into focus–visuals, materials, and movement - by drawing attention to the manner in which we respond to a hand wave, or the touch of a textured material or the pace and sensation of a breath. We invited movement tasks that promoted curiosity, complexity and playful interactions. This increased the variety of body actions, relational dynamics and spatial dimensions that we were able to explore. The preliminary prototype intervention is called emitts®, which is a pair of fingerless mitts with responsive light emitting components and bluetooth connectivity to generate screen effects. In response to the feedback that the whole experience of anticipating and exploring with emitts must be irresistible, we have created bespoke packaging that is designed to make using emitts as stress-free and playful as possible. The prototype is showing potential for enticing older people to re-discover the joy of moving, yet the prototype is yet to be tested and developed further. As such, the longer term impact of what it may offer in a care setting has yet to be fully evaluated. The prototype has been developed to encourage the freedom to explore, as it enables a heightened sensation whereby new movements draw attention to the capability of the hand and the rest of the body may follow - as one is able. Whilst a screen could place the attention outside of the body–as we are so easily mesmerised by dynamic, interactive visuals on a screen–emitts draw attention back to the body rather than to remove it–that could allow for a heightened sensation of movement.

We have reframed movement and the conditions that could allow for a movement practice that has agency and value in variation. Our main contribution is conceptual in that we offer a set of conditions for reframing movement, as social, sensate and relational in support of health and rehabilitation goals. These new effects and sensations may give a renewed appreciation of movement, beyond tasks and health goals. The removal of instruction can make it easier to be curious about the smallest of movements and lead to a variety of extensions. With the methods and the prototype described in this article, we wish to contribute to a knowledge transfer between the arts and health disciplines. Movement belongs to both, is studied by both and is a concern for both. The expert groups were able to find unity in their expertise within this frame. The iterative workshops, and the reflection and analysis that took place between each, informed how one could develop technology towards increasing movement, access and agency. To this end, the notion of the irresistible was crucial to initiating movement. When an ageing body contracts rather than expands, prescribed movements may become too instructed, too foreign and simply, too tedious.

In this articulation of an arts and movement project, our intention has been to make the case for applying rigorous, artistic processes in health, care and wellbeing contexts. Deliberately using movement as method, development and outcome, we have been able to draw out conditions for creating curiosity, engagement with and joy of one's aged body.

Data availability statement

The data presented in this article are available on the MMI online repository: http://makingmovementirresistible.org.

Ethics statement

Ethics was approved by Cardiff Metropolitan University, School of Art and Design Research Ethics Committee in accordance with national and international research ethics guidelines/standards. The participants provided their written informed consent to participate in this study—reference number: M02_22_B(WKB).

Author contributions

LH: Writing–original draft, Writing–review and editing. WK-B: Writing–original draft, Writing–review and editing. FN: Writing–original draft, Writing–review and editing. HW: Writing–original draft, Writing–review and editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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Neural effects of multisensory dance training in Parkinson's disease: evidence from a longitudinal neuroimaging single case study

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Dance is associated with beneficial outcomes in motor and non-motor domains in Parkinson's disease (PD) and regular participation may help delay symptom progression in mild PD. However, little is known about the neurobiological mechanisms of dance interventions for PD. The present case study explored potential neuroplastic changes in a 69-year-old male with mild PD participating in regular dance classes over 29 weeks. Functional MRI was performed at four timepoints (pre-training, 11 weeks, 18 weeks, 29 weeks), where the individual imagined a dance choreography while listening to the corresponding music. Neural activity was compared between dance-imagery and fixation blocks at each timepoint. Analysis of functionally defined regions revealed significant blood-oxygen-level-dependent (BOLD) signal activation in the supplementary motor area, right and left superior temporal gyri and left and right insula, with modulation of these regions observed over the training period except for the left insula. The results suggest the potential for dance to induce neuroplastic changes in people with PD in regions associated with motor planning and learning, auditory processing, rhythm, emotion, and multisensory integration. The findings are consistent with dance being a multimodal therapeutic activity that could provide long-term benefits for people with PD.

KEYWORDS

Parkinson's disease, fMRI, dance, neurorehabilitation, neuroplasticity, learning, motor imagery

1 Introduction

Parkinson's disease (PD) is a neurodegenerative condition in which a loss of dopamine-producing neurons in the substantia nigra pars compacta leads to motor symptoms such as bradykinesia, tremor, rigidity, and postural instability. People living with PD also experience a range of non-motor symptoms including depression, anxiety, and apathy

(Poewe, 2008). Currently PD is incurable, but treatments such as dopaminergic medication and deep brain stimulation (DBS) can help to alleviate symptoms and improve quality of life (Lee and Yankee, 2022). However, while medical and surgical treatments can be effective, they are associated with risks and side effects. For example, levodopa, the most common medication for PD, improves motor impairments but can lead to structural alterations in the brain causing complications such as dyskinesia (Ogawa et al., 2021). Additionally, while DBS can be effective for some individuals, costs of surgery are substantial and intensive post-surgery care is needed (Lozano et al., 2019; Erdem et al., 2022). The importance of non-invasive and non-pharmacologic approaches such as physiotherapy, exercise, and dance is increasingly recognized, particularly as the burden to healthcare systems continues to grow at an unsustainable rate with the increasing prevalence of PD (Dorsey et al., 2018).

Dance is a complex form of human movement which activates an intricate network of regions in the brain (Dhami et al., 2015). Engaging these areas of the brain through dance training facilitates structural and functional changes assumed to reflect more efficient functioning in expert dancers (Bar and DeSouza, 2016; Burzynska et al., 2017). Numerous studies have associated dance with improvements in motor functioning as well as non-motor symptoms in people with PD (for reviews see Bek et al., 2020; Kshtriya et al., 2015). Although few studies have examined the effects of long-term dance training in PD, a recent 3-year longitudinal study found evidence that regular dance participation may delay progression of motor and non-motor symptoms in people with mild PD (Bearss and DeSouza, 2021).

Dance training has been found to promote neural plasticity in professional dancers (Bar and DeSouza, 2016; Burzynska et al., 2017). For example, Bar and DeSouza (2016) found that learning a new dance choreography over 8 months was associated with a significant decrease in activation in the supplementary motor area (SMA) and the left and right auditory cortices. In older adults, behavioral changes resulting from dance training have been associated with structural and functional changes in the brain such as increased functional connectivity, increased white matter integrity, and increased volume in cognitive and motor regions (Rehfeld et al., 2018; Teixeira-Machado et al., 2019; Balazova et al., 2021; Meulenberg et al., 2023).

A recent study investigating the neuroplastic effects of dance for people with PD found changes in activation in areas of the motor cortex and cerebellum after 12 weeks of a Tango intervention (Kashyap et al., 2021). A previous single case study of an individual with PD also found an increase in functional connectivity between the basal ganglia and premotor cortex after 5 days of dance training (Batson et al., 2014). However, the neural mechanisms underlying motor improvement through long-term dance participation remain largely under-investigated in people living with PD (Meulenberg et al., 2023).

The present case study reports a longitudinal investigation of an individual with PD participating in regular dance classes over a period of 29 weeks, as part of a larger study to identify potential indicators of neuroplastic changes associated with dance training (Bearss and DeSouza, 2021). Functional magnetic resonance imaging (fMRI) was performed at four timepoints across the training period, to examine modulation of cortical activity when the individual imagined dance while listening to the music associated with the learned choreography.

2 Methods

2.1 Participant characteristics

The participant was a 69-year-old male with mild idiopathic PD with disease duration of 4 years and a Unified Parkinson's Disease Rating Scale (MDS-UPDRS) (Goetz et al., 2007) motor score of 12, who was taking dopaminergic medication at the time of the study. The participant was left-handed according to the Edinburgh Handedness Inventory (Oldfield, 1971). In addition to participation in weekly dance classes, the participant also reported regularly walking 6 miles per week. The participant had no previous dance experience. The study was approved by the Office of Research Ethics committee at York University (REB#2013–211). All procedures were conducted in accordance with the requirements of the ethical approval and the Declaration of Helsinki. The participant provided written informed consent prior to the data collection.

2.2 Dance training

The participant attended weekly specialist dance classes (75 min in duration) taught by Dance for PD trained instructors at Canada's National Ballet School (NBS) in Toronto, Ontario. Classes were attended by an average of 20 people with PD, with 15–20 trained volunteers assisting as needed. The dance classes included elements of jazz steps, ballet, Argentinian tango, dance theater, freestyle and choreographed movements, accompanied by live music from a pianist. Each class included a warm-up followed by seated and standing exercises, before practicing a 2-min choreography facing a partner (see Supplementary Table S1, for an example dance class outline). Sections of the choreography were based on a narrative, which the instructor would first describe before demonstrating the movements. A video illustrating part of the choreography is available at: https://bit.ly/42cMlth. While no structured training was provided outside of classes, the music accompanying the choreography was provided and the participant reported self-directed practice of the dance at home for approximately 4.5 h per week as well as 0.5–1 h per week imagining the dance with and without physical practice.

2.3 Scanning procedure

The participant underwent a series of 4 fMRI scanning sessions over a period of 29 weeks. Prior to each scanning session, safety screening was completed and training for the dance-imagery task was provided.

A 3 T Siemens Tim Trio MRI scanner was used to acquire functional and anatomical images using a 32-channel head coil. T2*-weighted echo planar imaging was performed using parallel imaging (GRAPPA) with an acceleration factor of 2X with the following parameters: 32-slices, 56 × 70 matrix, 210 mm × 168 mm FOV, 3 × 3 × 4 mm slice thick, TE = 30 ms, flip angle of 90°, volume acquisition time of 2,000 ms. Each scan consisted of 240 volumes. Echo-planar images were co-registered with the high-resolution (1 mm^3) anatomical scan of the participant's brain taken at the end of each session (spin echo, TR = 1,900 ms, TE = 2.52 ms, flip angle = 9°, 256 × 256 matrix). The participant's head was secured in place with cushions to minimize movements.

While in the scanner, the participant was instructed to imagine the choreography practiced during training in the dance studio, from a first-person perspective (including both visual and kinesthetic modalities), while the first minute of the music associated with the 2-min choreography was played through headphones. A block-design was employed where 60 s of the dance-imagery task (ON state) alternated with fixation blocks of 30 s (OFF state). These blocks were alternated and repeated five times for both blocks with a total scan time of 8 min (the first 15 volumes are not included in the analysis). The four timepoints were: pre-training (T1), where the participant had only attended one class with the music and choreography to be learned; after 11 weeks of training (T2); after 18 weeks of training (T3) and after 29 weeks of training (T4).

2.4 Data processing and analysis

Processing and analysis of the fMRI data was conducted using BrainVoyager QX (version 22.4.2, Brain Innovation, Maastricht, The Netherlands). Functional data were superimposed on an anatomical scan and transformed into Talairach space. Pre-processing steps (slice time correction, motion correction, and temporal high pass filtering) were applied to all runs. To account for periodic fluctuations in the fMRI signal, a General Linear Model (GLM) incorporating Fourier basis functions was applied, including two sine and two cosine functions to model low-frequency drifts and physiological noise. Across the four timepoints, the maximum motion correction did not exceed 1 mm for translation and 3 mm for rotation. None of the scans was excluded because of head movements. A fixed effects single-subject (FFX GLM) analysis was subsequently performed to compare activity during the dance-imagery blocks and the fixation blocks within each timepoint (T1, T2, T3, and T4). Functionally defined regions were identified from the GLM of dance-imagery versus fixation across all four timepoints, according to a statistical threshold of $p < 0.0001$ (Bonferroni-corrected) with a cluster threshold of $k > 22$. The BOLD percent signal change was calculated relative to a baseline, defined as the average of the two volumes acquired prior to the start of the music.

Modulation of task-related BOLD signal change (dance-imagery vs. fixation) was compared between timepoints for each of the functionally defined regions, using linear mixed-effects models to examine the effect of Time on percentage BOLD signal change associated with the dance-imagery task. The statistical models included Time (T1/T2/T3/T4) as a fixed factor with T1 as the reference level, as well as random effects for individual samples. An autoregressive correlation structure of order 1 [AR (1)] was included to account for correlations between consecutive samples. An adjusted significance threshold of $p < 0.0033$ was used to correct for multiple comparisons within and between models. Statistical analyses were conducted in R (R Core Team, 2023).

3 Results

Functionally defined regions based on clusters of functional activation across all four timepoints were identified from the GLM. These regions were SMA, left and right superior temporal gyrus (STG), and left and right insula, which were significantly activated at a statistical threshold of $p < 0.0001$ (Bonferroni-corrected) with a cluster threshold of $k > 22$ (see Figure 1). Talairach coordinates for these regions are provided in Supplementary Table S2.

Linear mixed-effect modelling revealed significant modulation of BOLD signal activation in the SMA (using the adjusted significance threshold) at T2 ($b = -0.35$, SE = 0.055, $t(413) = -6.32$, $p < 0.001$) and at T4 ($b = -23$, SE = 0.054, $t(413) = -4.19$, $p < 0.001$), but not at T3 ($b = -0.09$, SE = 0.054, $t(413) = -1.70$, $p = 0.09$), relative to T1. As illustrated in Figure 2, activation decreased from T1 (pre-training) to T2 (11 weeks of training), followed by an increase from T2 to T3 (18 weeks of training) and a subsequent decrease at T4 (29 weeks of training).

Significant modulation of BOLD signal was also found for the right STG at T2 ($b = -1.0$, SE = 0.075, $t(412) = -13.21$, $p < 0.001$), T3 ($b = -0.41$, SE = 0.074, $t(412) = -5.49$, $p < 0.001$), and T4 ($b = -0.95$, SE = 0.074, $t(412) = -12.84$, $p < 0.001$), and the left STG at T2 ($b = -0.73$, SE = 0.074, $t(413) = -9.87$, $p < 0.001$) and T4 ($b = -0.48$, SE = 0.073, $t(413) = -6.51$, $p < 0.001$), but not T3 ($b = -0.10$, SE = 0.073, $t(413) = -1.35$, $p = 0.18$). As shown in Figure 3, the changes in activation between timepoints for both right and left STG followed a similar pattern to the SMA, with an initial decrease from T1 to T2 followed by an increase from T2 to T3 and then a decrease at T4.

The right insula also showed a similar pattern (Figure 4), with a significant effect of Time at T2 ($b = -0.26$, SE = 0.075, $t(415) = -3.46$, $p = 0.0006$) and T4 ($b = -0.33$, SE = 0.074, $t(415) = -4.49$, $p < 0.001$), but not at T3 ($b = -0.17$, SE = 0.074, $t(415) = -2.28$, $p = 0.023$). Finally, the left insula did not show any significant effects of Time (all $p > 0.004$).

4 Discussion

The findings of the present case study suggest that, in an individual with mild PD, long-term dance training promoted functional changes in cortical regions while imagining the dance learned during classes.

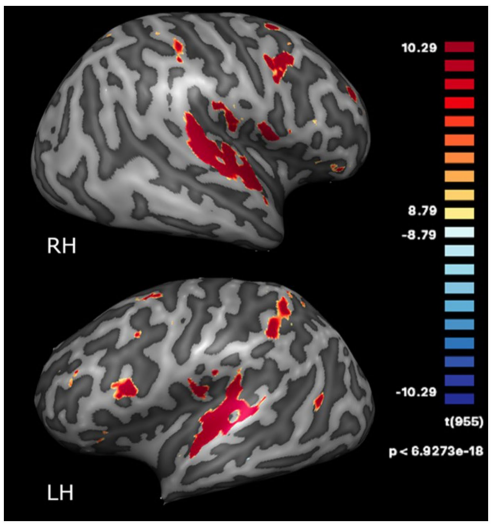

FIGURE 1
Regions activated during the dance-imagery task (vs. fixation) projected onto the inflated cortex of the right (RH) and left (LH) hemispheres, displayed at a statistical threshold of $p < 0.0001$, Bonferroni-corrected, cluster threshold $k > 22$.

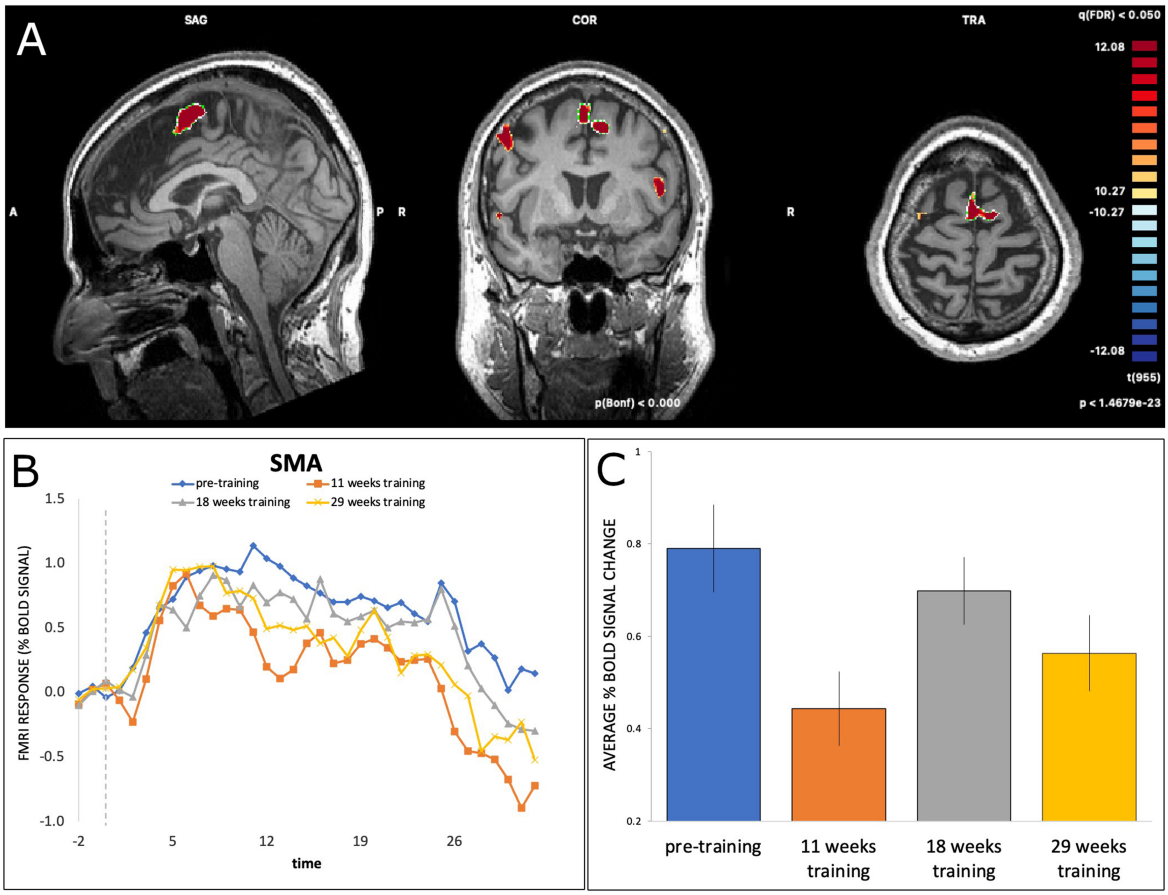

FIGURE 2
(A) BOLD activation of SMA during dance-imagery shown in sagittal, coronal, and transverse view in the 3D Talairach space, displayed at a statistical threshold of $p < 0.0001$, Bonferroni-corrected, with cluster threshold $k > 22$; **(B)** fMRI response (average percent BOLD signal change) of SMA during the dance-imagery blocks within each of the four timepoints (dashed line indicates the start of the music played in the scanner); **(C)** average percent BOLD signal change of SMA between the four timepoints. Error bars represent S.E.M.

The SMA, which is implicated in processes of motor planning, preparation and imagery (Shima and Tanji, 1998; Shima and Tanji, 2000; Lotze and Halsband, 2006), was significantly activated during all four timepoints. The SMA has been found to be activated in people with PD during motor imagery (Cunnington et al., 2001; Weiss et al., 2015), to a similar degree as in healthy controls (Cunnington et al., 2001). In previous work applying the same paradigm as the present study to expert dancers, activations were found in SMA and primary motor cortex (M1) (Bar and DeSouza, 2016), further indicating the role of motor processes during imagined dance. The high initial level of activation in the SMA at T1, when the participant had minimal experience of the music and choreography, might reflect the novelty of the music and/or difficulty in generating motor imagery. Consistent with the latter point, neural activity in people with PD when performing an implicit test of motor imagery (hand laterality judgment) has previously been found to increase with task difficulty in areas including the SMA (Helmich et al., 2007). At T2, a decrease in SMA activity was observed, following 11 weeks of dance classes learning the choreography alongside additional imagery practice with the music at home. This decrease might indicate a reduction in the demands of generating imagery, since the dance choreography was now familiar but not fully learned. The initial pattern of decreasing activation in SMA from T1 to T2 is also consistent with the findings of Olshansky et al. (2015), where decreased activation in this region was found during motor imagery with familiar music compared to unfamiliar music. The pattern of activation also suggested a subsequent increase in SMA activation at 18 weeks into training (T3), which might reflect greater generation of imagery as learning progressed (e.g., more sustained or more detailed images), followed by a decrease at the final timepoint (T4). In expert dancers, a decrease in SMA activation was found after 34 weeks of learning a new choreography (Bar and DeSouza, 2016), indicating greater ease or efficiency of motor imagery over time. In previous investigations of music and familiarity, the SMA and auditory regions were found to be activated when music was familiar, together with other motor-related regions such as the basal ganglia, cerebellum, and dorsal premotor cortex, further suggesting a pattern of motor-related activations (Zatorre et al., 2007). Additionally, recent self-report data indicated that music can evoke motor imagery in people with PD (Poliakoff et al., 2023), and that the vividness of music-evoked motor imagery correlated with musical training and the urge to dance.

The present analysis did not examine functional activity in the pre-SMA, which is a subregion of the SMA located rostral to the SMA-proper. While both areas are involved in motor planning and

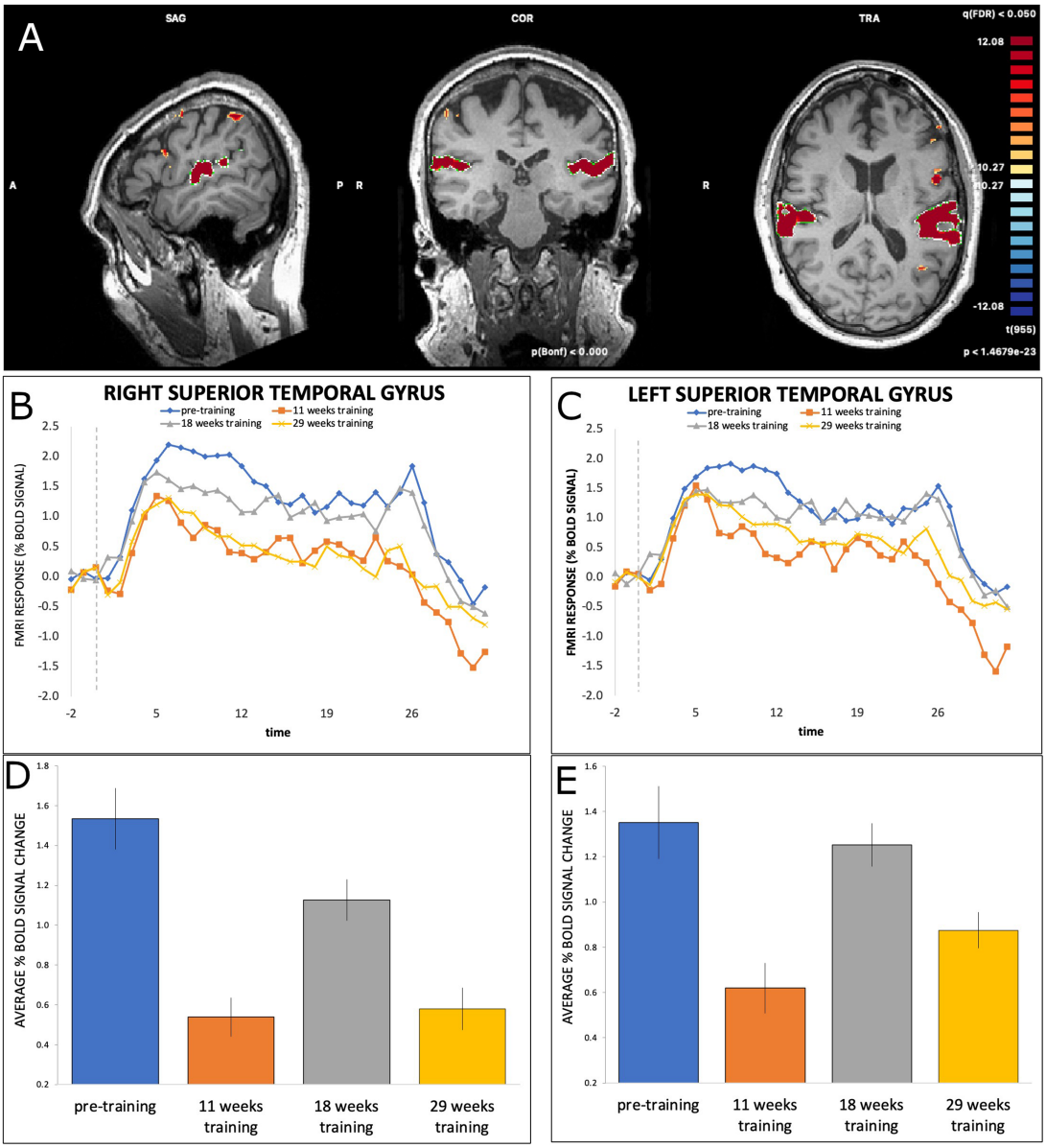

FIGURE 3
(A) BOLD activation of right and left STG during dance-imagery shown in sagittal, coronal, and transverse view in the 3D Talairach space, displayed at a statistical threshold of $p < 0.0001$, Bonferroni-corrected, cluster threshold $k > 22$; **(B,C)** average percent BOLD signal change of right and left STG during dance-imagery blocks within each of the four timepoints (dashed line indicates the start of the music played in the scanner); **(D,E)** average percent BOLD signal change of right and left STG between the four timepoints. Error bars represent S.E.M.

sequencing (Shima and Tanji, 1998; Shima and Tanji, 2000), the pre-SMA may be more involved in learning new motor sequences, due to its connections with prefrontal areas that are involved in learning and performing movement sequences (Shima and Tanji, 1998; Shima and Tanji, 2000; Hikosaka et al., 1996). The pre-SMA may also be more involved in inhibition of action (Obeso et al., 2013), compared to the SMA-proper which has more dorsal connections. The function of the pre-SMA may also be more impacted in PD than the SMA-proper (Cunnington et al., 2001). Future studies could thus attempt to differentiate the effects of dance training on activity of the SMA-proper and the pre-SMA in people with PD.

The bilateral STG, which have a key role in auditory processing (Rivier and Clarke, 1997) showed a similar pattern of activity to the SMA across the four timepoints, which was also similar to findings from expert dancers (Bar and DeSouza, 2016). In the present study, 29 weeks of training with the same music and choreography promoted an overall decrease in the STG activation in both hemispheres. One possible explanation of this is that novel music strongly activates auditory regions, and this activation decreases with familiarity (Olshansky et al., 2015).

The right and left insula were activated across all timepoints in the present study, but only the right insula showed a significant change across time. In humans, the insula has connections with neural structures such as the frontal, parietal, and temporal lobes, the cingulate gyrus, amygdala, brainstem, thalamus, and basal ganglia (Flynn, 1999). Multiple functions of the insula have been proposed,

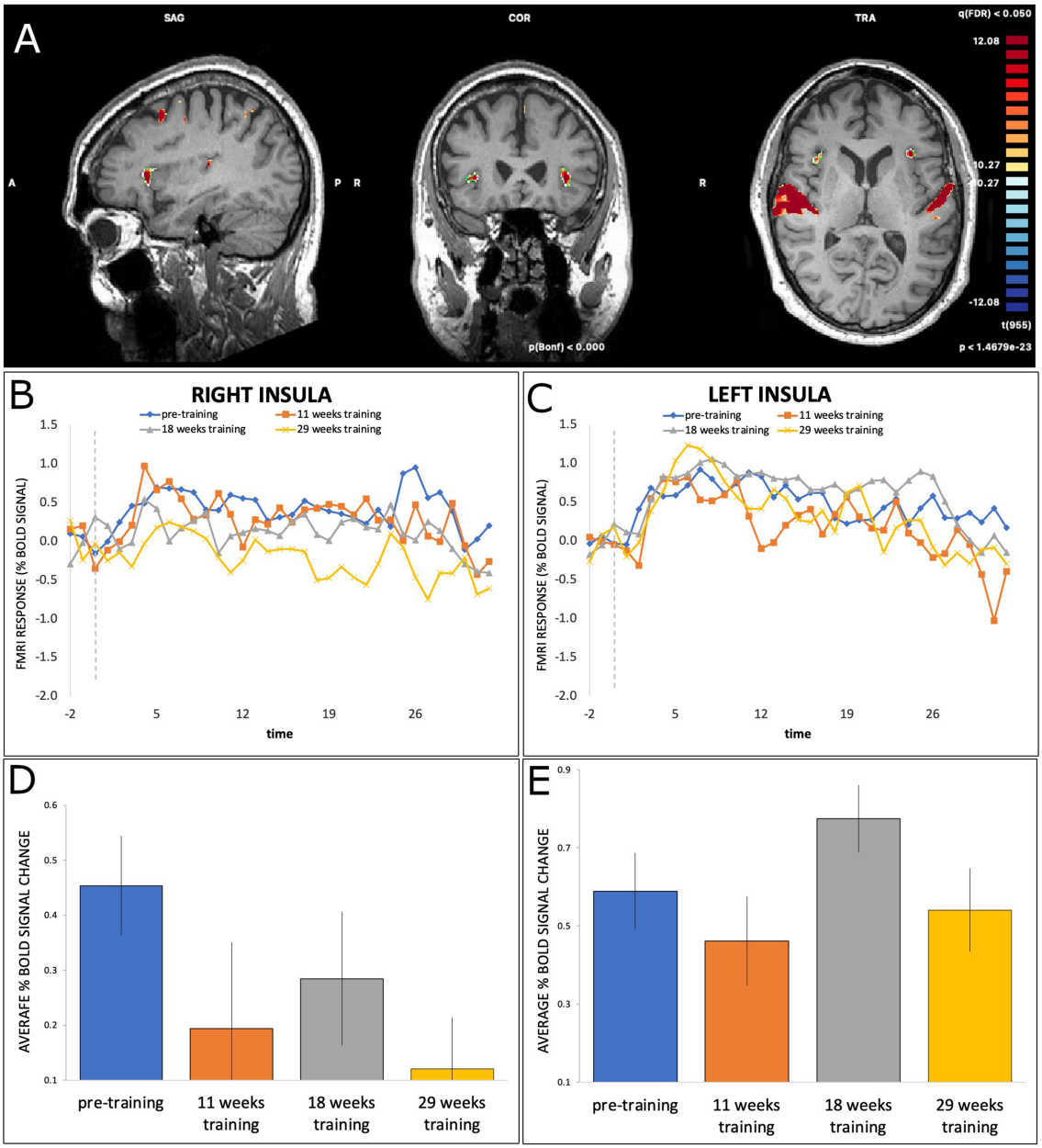

FIGURE 4
(A) BOLD activation of right and left insula during dance-imagery shown in in sagittal, coronal, and transverse view in the 3D Talairach space, displayed at a statistical threshold of $p < 0.0001$, Bonferroni-corrected, with cluster threshold $k > 22$; **(B,C)** average percent BOLD signal change of right and left insula during dance-imagery blocks within each of the four timepoints (dashed line indicates the start of the music played in the scanner); **(D,E)** average percent BOLD signal change of right and left insula between the four timepoints. Error bars represent S.E.M.

including sensorimotor processes such as body awareness, error awareness, attention to pain, and representing the physiological condition of the body (Craig, 2009). In addition, the insula has been proposed to provide an interface between body awareness and movement (Tinaz et al., 2018).

The present study found an asymmetry in activation between right and left insula, which may be due to the differences between ascending and descending connections that utilize different frequency bands depending on feedforward or feedback communication (Bastos et al., 2015) or anatomical connections (Rivier and Clarke, 1997). The right insula has been found to be more activated by visual and auditory perception of emotional music (Petrini et al., 2011) as well as processing of rhythm (Lappe et al., 2013) and melody (Thaut et al., 2014) compared to the left. Moreover, the right insula has been suggested to be important for multisensory integration (Chen et al., 2015) and in the present study may have been involved in integrating sensory aspects of the imagined movement with the music. The insula has also been suggested to act as a hub for connecting attentional control and memory related regions (Mayer et al., 2007); thus, it is also possible that the decrease in activation of the right insula in the present study reflects reduced demands on attentional processing,

emotion processing and/or memory. Further evidence for a role of the insula in dance was found in a study of older adults (Rehfeld et al., 2018), in which dance training was associated with an increase in grey matter in various brain regions including the left insula, when compared to an active control group who practiced repetitive movements. These findings contrast somewhat with the present study, where a clearer change in activation was found for the right than left insula. However, the previous study emphasized continual learning of different movements and choreographies, which may differently recruit the insula; for example, the left insula appears to be more involved in speech and language processing (Oh et al., 2014), which may be important for following instructions for new dance routines. Moreover, we did not analyze structural changes, which may reveal different effects than functional data.

While previous studies of dance for PD have not examined neuroplastic effects in the same regions as investigated in the present study, some evidence of functional neural changes resulting from dance training has been reported in PD as noted above (Kashyap et al., 2021; Batson et al., 2014). Neuroplastic effects of other forms of physical activity, such as aerobic exercise and treadmill training, have also been documented in people with PD (Duchesne et al., 2016; Maidan et al., 2017; Johansson et al., 2020), although one study found that activation of sensorimotor areas and cerebellum did not change during imagined gait following a 12-week program of either Tango or treadmill training (Myers et al., 2018). In addition, evidence of functional changes in brain areas related to motor imagery, alongside improved motor imagery vividness, was found following training with action observation and motor imagery in participants with PD (Sarasso et al., 2023). Since dance involves observation and imagery of movement (Bek et al., 2020), the neural changes indicated by the present study may thus reflect both motor learning of the dance choreography and improved motor imagery ability.

The present study has several limitations that should be addressed in future work to further understand the neural effects of dance for people with PD. Although the results of a single case study cannot be generalized, this study provides proof of concept of a dance learning paradigm that can be applied to larger numbers of participants to investigate neuroplastic effects of dance. Future studies should compare participants receiving dance training to participants in a control condition, such as an exercise program or no intervention. It would also be informative to collect longitudinal data on performance or recall of the dance choreography, as well as disease status (e.g., UPDRS) to examine in relation to changes in functional activation. In the present study, it cannot be ruled out that stress or anxiety contributed to the high levels of BOLD activity observed at the first timepoint, and this could be addressed in future studies by incorporating physiological measures such as skin conductance and heart rate. Additionally, although the present study provides initial evidence that regular dance participation could promote neuroplasticity in people with PD, it is important to note that the participant in this case study might not be representative of a typical person with PD, given his high level of physical activity including additional dance practice (both physical and via imagery) outside of classes. Moreover, given the heterogeneous nature of PD, the neural effects of dance may differ between participants at different disease stages or with different symptom profiles. Future research with larger samples could investigate this by comparing groups of participants with different subtypes of PD. Alternatively, heterogeneity could be better controlled by focusing only on one subtype, as some previous fMRI studies have done (Sarasso et al., 2023). Finally, since difficulties with motor imagery are sometimes reported in PD (Scarpina et al., 2019; Readman et al., 2023), future studies could also screen participants to ensure an adequate level of imagery ability, as well as providing training on the use of motor imagery prior to undertaking the fMRI protocol.

5 Conclusion

In conclusion, the findings of this case study indicate the potential neural effects of dance for people with PD, through activation of multiple brain networks associated with movement, planning, imagery, and auditory and emotional processing.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by Office of Research Ethics committee at York University (REB#2013-211). The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study. Written informed consent was obtained from the individual(s) for the publication of any potentially identifiable images or data included in this article.

Author contributions

JS: Writing – review & editing, Writing – original draft, Visualization, Formal analysis. JB: Writing – review & editing, Writing – original draft, Visualization, Supervision, Formal analysis. KG: Writing – review & editing, Formal analysis. KB: Writing – review & editing, Data curation. REB: Writing – review & editing. RJB: Writing – review & editing, Investigation, Data curation, Conceptualization. JD: Writing – review & editing, Visualization, Supervision, Project administration, Methodology, Investigation, Funding acquisition, Data curation, Conceptualization.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

The author(s) declared that they were an editorial board member of Frontiers, at the time of submission. This had no impact on the peer review process and the final decision.

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Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fnagi.2024.1398871/full#supplementary-material

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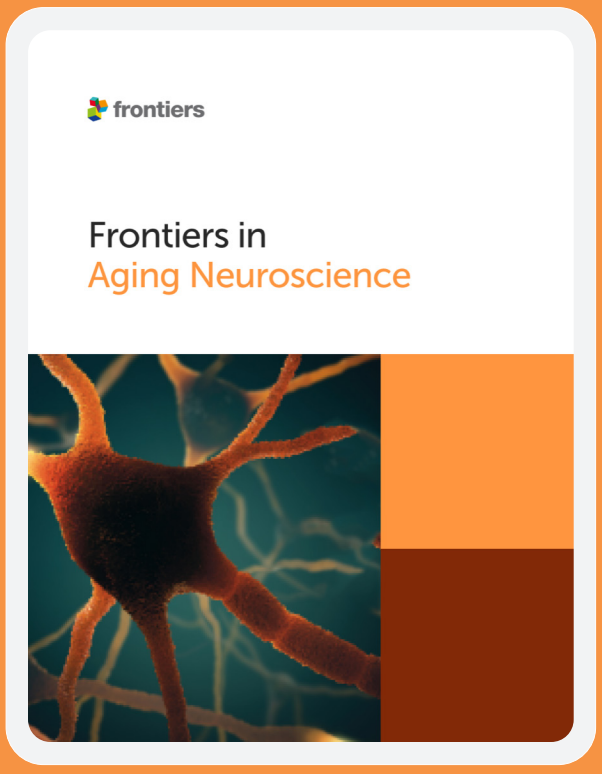

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