Effects of a ballet-based dance intervention on gait variability and balance confidence of people with Parkinson's

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Abstract

Background: Dance has shown to be beneficial for people with Parkinson's. However, there is a lack of research on ballet for this population. The present study aimed to determine the effect of weekly ballet classes on gait variability and balance confidence for people with Parkinson's.

Methods: The study follows a non-randomized, controlled project evaluation design. A group of 19 people with Parkinson's who were already involved in weekly ballet classes volunteered for this research. A control group of 13 people with Parkinson's were asked to not participate in dance classes across the duration of the study.

Results: The study did not demonstrate significant effects of weekly ballet classes on gait variability or balance confidence.

Conclusions: These findings differ from recent studies that suggest dancing can improve balance and gait for this population. There is a need to examine the optimal ballet class frequency required to elicit any potential positive change.

Keywords: Neurodegenerative Disease – Dancing - Postural Balance

Introduction

Loss of balance and stability is a common symptom of Parkinson's that causes much difficulty for individuals in their everyday lives (Hackney & Earhart, 2010; Hackney, Kantorovich, & Earhart, 2007). Individuals with Parkinson's are at a much higher risk of falling compared to age-matched controls and these falls can lead to a multitude of injuries, a fear of falling, decreased balance confidence, and a subsequent lack of participation in activities and in society (Hausdorff, 2009; Schaafsma et al., 2003). As a result, balance problems can have a detrimental impact on an individual's health-related quality of life and may be the source of low self-esteem and social isolation in many cases (Bloem, Grimbergen, Cramer, Willemsen, & Zwinderman, 2001).

Recent studies examining the effects of physical activity for this population have attempted to understand how balance can be improved (Ashburn et al., 2007; Schenkman et al., 2012). In recent years, dance has proven to be a beneficial component to treatment for people with Parkinson's with multiple studies showing improved balance and functional mobility, as well as improvements in a range of quality of life factors (Batson, 2010; Hackney et al. 2007; Heiberger et al., 2011).

To date, studies in the 'dance for Parkinson's field' have only postulated about how dance, in a variety of forms, may be affecting balance (Earhart, 2009). No studies have directly measured the mechanisms of change or exactly how specific dance movements are influencing stability within this group of people. Instead, recent studies have only suggested that the practice of weight shift, quick changes of direction, and the teaching of movement strategies may be cause for the improved balance and gait after a dance intervention (Earhart, 2009; Hackney et al., 2007).

There is reason to suggest that ballet exercises would have a positive impact on gait and balance confidence for this group of people. A variety of movements in a ballet class require the participant to stabilize on one leg while moving the other leg through a range of motion, as is seen in a *tendu* or *rond de jambe* action. Furthermore, travelling sequences across the floor encourage efficient transfer of weight and an understanding of how to bring the centre of mass over the base of support to re-stabilize while in motion. Thus, it is important to understand more about how ballet could potentially benefit people with Parkinson’s, and specifically their stability.

Many studies have relied on clinical rating scales such as the Berg Balance Scale (Berg, Wood-Dauphinee, Williams, & Maki, 1992) and the One Leg Stance test (Fregly & Graybiel, 1968; Smithson, Morris, & Iansek, 1998) to assess functional changes in stability after a dance intervention. However, recent research has expressed concern that these scales might be assessing efficiency of completing specific tasks rather than changes to balance overall (Houston and McGill, 2013). Furthermore, these rating scales do not distinguish between stability in standing (static) and stability in motion (dynamic), with some of the most common measures in the field only assessing static balance. There is a need to better understand the significance of stability during common functional activities such as walking.

Gait instability and arrhythmicity, resulting in higher stride-to-stride variability, are characteristic features of Parkinsonian gait (Schaafsma et al., 2003). Several research papers have noted that the measurement of gait variability specifically relates more to fall risk than the measurement of other cardinal symptoms such as tremor, rigidity, and bradykinesia

(Hausdorff, 2009; Schaafsma et al., 2003). Analysis of acceleration signals reflecting movements of the centre of mass has proven to be useful in the measurement of gait variability (Moe-Nilssen, 1998).

McGill, Houston, and Lee (2014) argue that it is important to understand how changes to physical impairments are impacting upon participants' daily lives and activities. With regards to balance and changes to dynamic stability, it is important to understand how the participants feel about their ability to remain stable and safe in everyday tasks and situations. However, few studies to date have included measures of balance confidence and some that have included this measure do not report on the findings (Marchant, Sylvester, and Earhart, 2010).

The present study aims to determine if weekly ballet classes can affect gait variability for a group of people with Parkinson's. This study will use gait variability as an indicative measure of dynamic stability. The study also aims to understand if participation in weekly ballet classes impacts upon balance confidence for this group of people.

Materials and Methods

Participants and Protocol

Participants in the dancing group were recruited from an on-going 'dance for Parkinson's' class. Control participants were recruited from a variety of local Parkinson's support groups and also through relationships with members of the dancing group. The research team was asked to evaluate and assess potential benefits of an already existing class for people with Parkinson's with a predefined protocol and as such this research follows a non-randomized, controlled, project evaluation design. It was not possible to randomize participants, nor was it ethically appropriate to ask participants to change their medication plans to fit their testing sessions. As such, the research tested participants at various levels of their daily condition.

Due to the nature of the research and the fact it was embedded within an arts-based project, new participants were continually joining the ballet classes and were offered the opportunity to take part in this research project across the 12-month duration of the study. A total of 19 people diagnosed with Parkinson's who were dancing once a week volunteered to take part in the research. A total of 13 control participants who were not involved in any dance classes volunteered to form the control group. All participants completed a health and information sheet at each testing session that asked about any changes to medications, recent falls, any other medical conditions, and any other physical activities they were taking part in on a regular basis. The researchers took an ethical stance that it would not be appropriate to ask dancing and control participants to stop other forms of activity across the duration of the study and thus they were asked to carry on with their normal activities.

Ethical clearance was gained through the Ethics Committee at the first author's affiliating University and all participants completed a consent form outlining details of the project prior to baseline measurement. Inclusion criteria set at the beginning of the study meant that all participants, both dancing and control groups, had to be over 55 years of age, show no signs of dementia (as assessed via the Mini-Mental State Exam (MMSE)), be able to walk, or attempt to walk independently with no walking aid, have no back injury or have had recent surgery on the back, and not have gone through Deep Brain Stimulation surgery. If participants met the inclusion criteria above, they were able to participate despite their stage of Parkinson's. All dance participants had been dancing prior to baseline measurement for at least one term (or 3 months). The majority of participants had been taking part in dance classes for one year or more prior to their baseline measurement. Participant characteristics are outlined in Table 1 below.

Table 1. Participant characteristics

	Age	Gender	Yrs Diagnosed	Stage of Parkinson's	UPDRS Motor Subscale Score	MMSE Score
Experimental Group	69.83 ± 4.55	10/9 (F/M)	6.78 ± 2.71	2.32 ± 0.48	29.42 ± 9.11	28.37 ± 1.57
Control Group	73.25 ± 8.09	7/6 (F/M)	5.75 ± 4.27	2.15 ± 0.55	31.69 ± 10.31	28.23 ± 1.64

* Stage of Parkinson's is presented using the Hoehn and Yahr scale

* UPDRS – Unified Parkinson's Disease Rating Scale; MMSE – Mini-Mental State Exam

* Experimental and Control Group are similar and do not differ statistically on these variables

The Dance Classes

The once-weekly sessions followed the same structure across the duration of the study. All classes lasted between 1.25 and 1.5 hours during term time (autumn, spring, and summer terms each lasting approximately 10-12 weeks). The classes were choreographed and taught by dance artists in the hosting ballet company's outreach department. As such, the research team had no influence on the movement material chosen for the sessions, the structure or level of intensity of the ballet classes, or the frequency of the sessions. The researchers were asked simply to analyse potential benefits of the weekly classes for the participants. The programme, which is still on going, uses the current company repertory as a basis for the content each term, however the material is tailored to the participants.

The first half of the class began seated and then progressed to standing and travelling movements. Table 2 below provides a more detailed description of class. However, it is important to note that each term the exercise choreography changed to reflect the piece of repertory being used as the basis for content. As such, the description below only provides a general overview of the basic structure and type of movement material used each term.

Table 2. Ballet exercises and content

Class Exercise	Content
Seated Warm up	Often included stretches of the torso in all directions with arms reaching overhead or out into the space. A focus on use of breath, posture, and weight distribution in the chair helped participants prepare for the work ahead. Participants would flex and extend the spine in an effort to find a balanced posture with both sitting bones equally weighted into the chair and a sense of floating in the upper body.
Seated Port de bras	The main emphasis was on movement of the arms and upper body with exercises that worked through basic ballet positions (1st – 5th positions of the arms as well as 1st, 2nd, and 3rd arabesque lines with use of épaulement). Participants were encouraged to engage/activate the muscles in the back of the body to hold the arms and use their eye focus
Seated Tendu, Battement and Rond de Jambe	These exercises emphasised movement of the lower body. Participants would stretch and bend the knees, point and flex the feet, and rotate in the hip joints. Legs were often kept low to the floor or just level to the knee and verbal cues encouraged participants to maintain a strong posture and core.
Rhythmic Exercises	These exercises included taps, claps, stamps, and marches in an effort to challenge coordination and wake up the body and mind. Participants would follow the instructor as she gave instructions challenging their reaction time and concentration.
Story Exercises	Incorporating many of the movement ideas above, these exercises aimed to set a scene and tell a story. Contrasting movement qualities (i.e. soft, sharp, slow, quick, heavy, light, etc.) and gestures were used to communicate different ideas and emotions. Use of expression and intention helped participants to communicate stories and embody various characters and themes.
Vocal Warm up	The musicians and dance artists worked together to introduce various vocal warm ups (i.e. singing vowels or chants that were relevant to the class theme). Awareness was drawn to how the rest of the body must support the vocal chords when expressing through sound. The voice provided another avenue of

	expression and intention alongside engagement of the body in stillness and in motion.
Standing Pliés at the Ballet Barre	While standing in various positions (i.e. parallel, 1st position in the feet, or 2nd position in the feet), participants would bend and stretch the knees placing the weight of the body equally across both feet. Verbal cues encouraged proper technique whereby the line of the knees should fall in line with the feet and an upright posture should be maintained with a sense of grounding into the floor.
Standing Tendues at the Ballet Barre	While standing in various positions (i.e. parallel or 1st position in the feet) participants would transfer their weight to one foot while the other leg would extend either front, side or back with the foot pointed. The leg would then draw back in placing equal weight on both legs and feet. This action would be repeated in different directions and on both legs.
Centre Walking	Participants would walk in different situations and environments. Sometimes they would walk/march around the room in no particular formation having to navigate their way through the crowd of dancers and negotiate the space around them. Other exercises encouraged participants to walk in formations or alongside a partner from one side of the room to the other with a sense of purpose and intent.
Performance Sequence	Basic ballet positions in the upper and lower body that were introduced in the seated exercises are revisited and strung together to create a small dance sequence. While the participants are walking/marching/moving in different directions and with different qualities, they are expressing and moving through ballet positions in the upper body. The sequence brings all of the elements of class together including stillness, motion, posture, breath, voice, and expression.
Mirroring	The dance artists often provide a movement idea or concept from class that participants can base their movement on. In partners one person begins to move and improvise while the other partner mirrors their actions. Halfway through the exercise they switch roles and the other partner leads the improvised movement.

The lead researcher attended and participated in the weekly sessions. Participation in the dance classes meant that the researcher was able to gather rich data about the participant experience that would not have been possible had the researcher not attended. As this study was part of a wider project that used a mixed methods approach to understand the potential physical, mental, social, emotional benefits for this group of people, inclusion and participation within the dance class was key to the research. However, this particular way of working meant that this study could not be blinded.

Step and Stride Variability Assessment

Numerous studies have assessed the temporal variability of gait patterns through autocorrelation of acceleration signals as a means of assessing dynamic stability in a particular population (Keenan & Wilhelm, 2005; Yang & Hsu, 2010; Yang, Hsu, & Shih, & Lu, 2011). Autocorrelation is the correlation of a signal with itself at different time lags. At zero lags two identical signals will produce a coefficient of one. At a particular phase shift the autocorrelation coefficient will be at its maximum again evidencing how similar the two signals are when the time lag is representative of one step. A coefficient value closer to one is representative of a stronger similarity between neighbouring steps. The coefficient values can thus provide information about the step and stride regularity, or variability, for a particular gait pattern and can be a useful tool during the assessment of dynamic stability (Moe-Nilssen & Helbostad, 2004; Yang et al., 2011).

To assess step and stride variability a single inertial sensor was placed at the sacrum of the participant (S2) and secured with double-sided tape. The inertial sensor wirelessly sent information to a receiving box attached to a computer. Linear acceleration data were gathered at a rate of 180Hz (Brach, McGurl, & Wert, 2011; Esser, Dawes, Collett, Feltham, & Howells, 2011; Moe-Nilssen & Helbostad, 2004). Moe- Nilssen (1998) discusses the validity of choosing the sacrum as a reference point which is close to and moves in parallel with centre of mass of the person. The present study chose a position on the sacrum of S2.

Participants were asked to walk from one side of the room to the other (a distance of 10m) at a self-selected, natural walking speed. In these conditions participants were not dealing with obstructions or external factors causing perturbations to balance. Rather, only perturbations caused by internal body systems would affect gait variability. In such conditions research has shown that healthy gait patterns demonstrate a more consistent rhythm as there is no need to adapt to external perturbations in such a controlled setting (Hausdorff, 2005; Terrier & Schutz, 2003). However, a certain level of gait variability may be useful in situations that require participants to have some level of flexibility to adapt to a changing environment. The aim of this research was not to look at participants' flexibility in gait patterns while responding to a changing environment but rather to assess their consistency of gait rhythm as an indication of dynamic stability in motion. As such, natural, unobstructed gait was most useful in understanding and achieving this aim.

Data was only recorded in one direction to avoid acceleration signals switching from positive to negative values and thus participants stopped after the 10m walk, data was saved, and the researcher and participant walked back to the same starting point to complete the rest of the trials. Each participant carried out three trials in total at each testing point.

Balance Confidence Assessment

Balance confidence was assessed in the present study using the Activities-Specific Balance Confidence Scale. The ABC is a 16-item scale asking participants to rate how confident they feel at attempting various tasks that require some level of stability. The scale provides an indication of participants' balance confidence in activities of daily living (Parry, Steen, Galloway, Kenny, & Bond, 2001; Powell & Myers, 1995). Myers, Fletcher, Myers, and Sherk (1998) suggest that an ABC total score between 50% and 80% is reflective of a moderate level of physical functioning whereas a score below 50% is indicative of a low level of physical functioning. Furthermore, Lajoie and Gallagher (2004) suggest that an ABC score below 67% may indicate a higher risk of falls for older adults and is a predictor of future falls.

Participants were asked to complete the questionnaire prior to attending their testing session. If they had any queries or concerns about any of the 16 questions, they were asked to make note of these issues and raise them with the researcher at their testing session.

Data Analysis

Gait and balance confidence data were analysed across the short term (3-5 months) and across a longer term (10-12 months). The short-term analysis looked at the potential impact of the ballet-based sessions after just one term (10-12 weeks) of dancing whereas the long-term analysis looked at potential changes across three terms. The researchers wanted to understand whether any potential changes happening in the short term would carry forward to the long-term analysis. Furthermore, the researchers understood that even if no significant changes were observed in the short term, it is possible that changes to dynamic stability could occur in the longer term. For each separate gait trial, five stride cycles were analysed from the middle of the data set with the first and last cycles avoided where possible to remove any data reflecting the start up or slowing down at the end of the walk. The five cycles were determined by using the vertical acceleration signals to locate heel strikes (Evans, Duncan, & Gilchrist, 1991). A single stride was represented by the heel strike of one foot and the time to the next point of contact where that same heel contacted the floor.

Prior to determining the 5 cycles for analysis, the vertical acceleration data was resampled using the Butterworth filter in Matlab. This allowed for a smoothing of the data.

Unbiased autocorrelation methods were used in Matlab with the <xcov> function serving to compute autocorrelation coefficients representative of step and stride variability. Autocorrelation was carried out with vertical acceleration data only due to the clarity of the signal in comparison to the anteroposterior and mediolateral directions. Recent research has suggested that movement in the vertical and anteroposterior directions are more closely related to gait stability than measures in the mediolateral plane (Latt, Menz, Fung, & Lord, 2009). With regards to balance confidence, scores for each of the 16 questions were totalled and divided by 16 to provide an average score.

Statistical Analysis

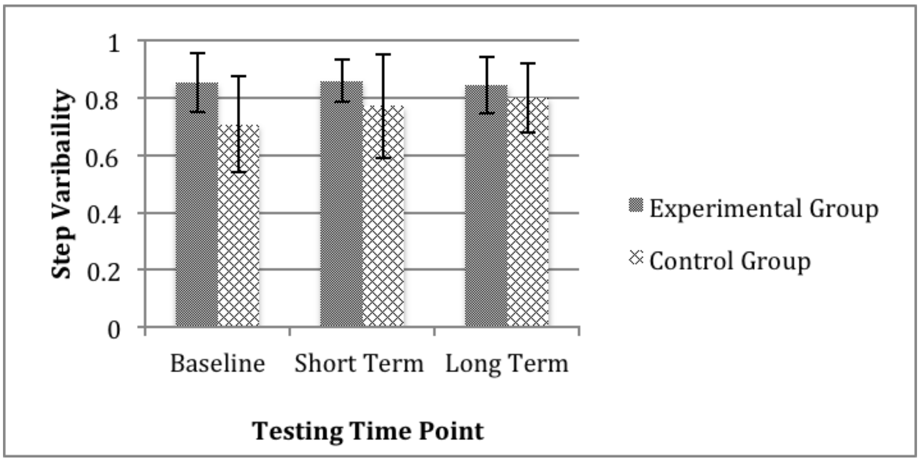
Normality tests (the Kolmogorov-Smirnov (K-S) test and Shapiro-Wilk test) showed that the data sets did not have normal distributions and thus it would not be appropriate to use parametric statistical tests. For all variables, the Friedman test was used to calculate changes across time in the dancing group and in the control group. Mann Whitney U tests were used to calculate differences between groups at each of the three time points (baseline, short term, and long term). A Spearman Rank Correlation was used to assess the relationship between gait variability and balance confidence in the short and long term. All statistical tests were carried out in SPSS with a significance level set at $p<0.01$.

Results

Step Variability

Figure 1 outlines changes to step variability across time for both dancing and control groups. While the dancing group fell slightly towards a more variable gait, the control group grew towards a more consistent step pattern. The dancing and control groups did not evidence any significant change across the duration of the study with respect to step variability (p=0.635 and p=0.15 respectively). There were also no significant differences between groups with respect to step variability (baseline (p=0.013), short term (p=0.317), long term (p=0.295)). However, it appears that the two groups grew to be more similar across the duration of the study. Additionally, the dancing participants always demonstrated a more consistent step pattern compared to control participants.

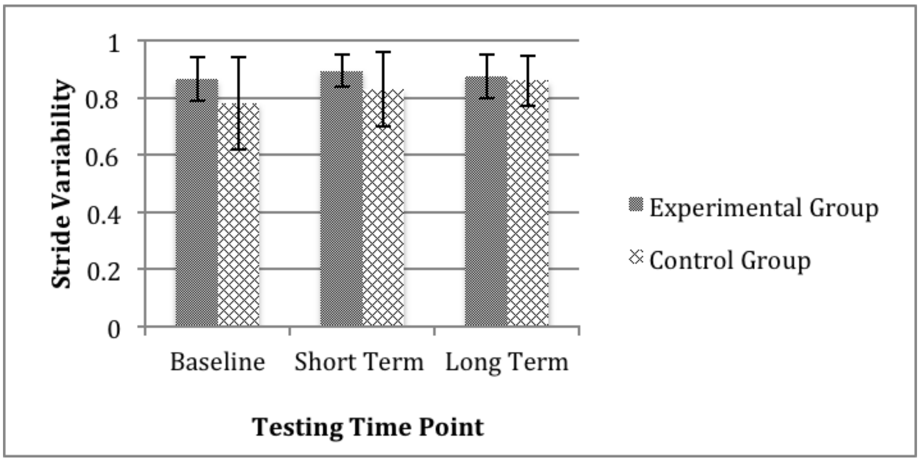
Figure 1. Changes to Step Variability



Stride Variability

Figure 2 outlines changes to stride variability across time for both dancing and control groups. Both groups saw a slight move towards a more consistent stride pattern by the end of the study. However these changes were not significant (p=0.199 and p=0.614 respectively). There were also no significant differences between groups with respect to stride variability (baseline (p=0.235), short term (p=0.299), long term (p=0.365)). Again, the two groups grew to be more similar across the duration of the study with the dancing participants always demonstrated a more consistent stride pattern compared to control participants.

Figure 2. Changes to Stride Variability



Balance Confidence

Figure 3 outlines changes to balance confidence across time for both groups. The dancing and control groups did not see any significant change in balance confidence across time (p=0.754 and p=0.087 respectively). Furthermore, there were no significant differences between groups across the duration of the study (baseline (p=0.58), short term (p=0.366), long term (p=0.267)). Both the dancing and control groups remained within the 50 to 80%

range throughout the duration of the study evidencing a moderate level of functioning (Myers et al., 1998). Across the study the control group fell below 67% thus putting them at a higher fall risk, whereas the dancing group began the study above a 67% confidence level and remained above this value throughout (Lajoie & Gallagher, 2004).

Figure 3. Changes to Balance Confidence

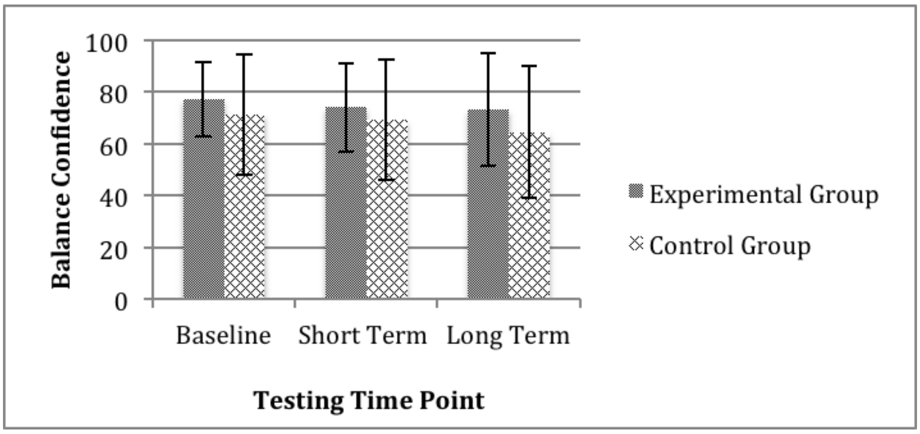


Table 3 below outlines the means and standard deviations for all variables across time for both dancing and control groups.

Table 3. Changes to Step Variability, Stride Variability, and Balance Confidence

	Dancing Group (n=19)			Control Group (n=13)		
	Baseline	Short Term	Long Term	Baseline	Short Term	Long Term
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
Step Variability	0.85 (0.10)	0.86 (0.07)	0.85 (0.10)	0.71 (0.17)	0.77 (0.18)	0.80 (0.12)
Stride Variability	0.86 (0.08)	0.89 (0.06)	0.87 (0.08)	0.78 (0.16)	0.83 (0.13)	0.86 (0.09)
Balance Confidence	77.33 (14.54)	74.05 (17.14)	73.28 (21.74)	71.38 (23.30)	69.13 (23.31)	64.38 (25.61)

Correlation between Step/Stride Variability and Balance Confidence

Short term

While there was a significant positive correlation between step and stride variability (r=0.797, p=0.000), there were no significant correlations between step variability and balance confidence (r=-0.370, p=0.063) or between stride variability and balance confidence (r=-0.177, p=0.388).

Long Term

While there was a significant positive correlation between step and stride variability (r=0.742, p=0.000), there were no significant correlations between step variability and balance confidence (r=-0.329, p=0.126) or between stride variability and balance confidence (r=-0.343, p=0.110).

Discussion

Our results are different to those of many other 'dance for Parkinson's' studies that have assessed changes in balance. While numerous studies in the field have shown positive improvements to balance after a dance intervention (Batson, 2010; Hackney & Earhart, 2010; Hackney et al., 2007; Marchant et al., 2010), our results show no significant changes in gait variability after 12-months of participation in a weekly ballet class. The reasons for this difference in result are two-fold. First, gait variability as an indication of dynamic stability has not been assessed in previous dance for Parkinson's research. Measures of gait variability are not necessarily comparable to other commonly used clinical rating scales that place more emphasis on static balance tasks (Moe-Nilssen, 1998). As gait variability is closely related to fall rates (Hausdorff, 2009; Maki, 2007; Schaafsma et al., 2003), the present study is providing new, useful information in demonstrating that once-weekly ballet classes did not have a significant effect on gait variability and potentially the risk of fall. Secondly, previous studies evidencing changes to balance, gait, and functional mobility have often included a class frequency of two to three dance classes per week (Hackney & Earhart, 2009; 2010; Hackney et al., 2007). It is possible that a frequency of one dance class per week will not elicit positive physical improvement for this group of people (Hackney & Earhart, 2010(b)). The present study found no significant effects on gait variability with a frequency of one ballet class per week. It is unclear what the effect will be with a different frequency and thus further investigation is needed.

High levels of adherence to the ballet programme indicated that the participants were motivated to continue attending. The majority of participants were able to attend over 50% of classes offered during any one term. Adverse weather conditions, problems with public transportation, and important family events that conflicted with the class timetable were the main reasons why participants were not always able to attend all classes each term. It is possible that the varied attendance levels also impacted upon the results. However, this varied attendance is likely to be a common issue among longer duration studies in the field.

To the authors' knowledge, this is one of the first studies in the field to look at a group of people with Parkinson's who had already been dancing prior to baseline measurement. As many participants had already been dancing for at least one year prior to baseline, the results may reflect the physical plateau that happens when there is a lack of overload on the body system. The principle of overload in exercise and conditioning research reinforces the need for consistent, incremental rises in training factors such as frequency, intensity, duration, and type of training (Shanahan, Morris, Bhriain, Saunders, & Clifford, 2014; Power & Clifford, 2013). With regards to the dance classes in the present study, the frequency and duration remained the same with some level of change in the intensity and type of dancing as a result of changes to choreography from term to term. However, these changes in intensity during the weekly sessions were not large enough to warrant significant changes in stability.

In relation to the above, it is possible that a ceiling effect may have occurred whereby any resulting change in gait variability as a result of the ballet-based sessions was no longer visible due to participants having already danced prior to baseline measurement. For the dancing group particularly, the variability measures were above 0.80 throughout the duration of the study and this value is higher than a fit elderly group examined by Moe-Nilssen in 2005. It is possible that the ballet-based sessions had a positive affect on gait variability for the participants, however the measurements were not able to capture this early change at the beginning of their dance programme.

McGill, Houston and Lee (2014) argue for the need to understand how potential physical changes impact upon activities of daily living and participation in society. These authors suggest that making these connections would help to develop more meaningful conclusions about the full impact dance is having on people with Parkinson's. The present study followed on from arguments made above and included an additional measurement looking at participant perceptions of balance confidence with regards to activities outside of the dance studio. Across the duration of the study there were no significant changes to balance confidence for the dancing and control groups. Since there were no such significant changes, it would be difficult to demonstrate any correlation between gait variability and confidence.

The design and methods used in the present study provided an effective and meaningful assessment of a dance intervention for people with Parkinson's. However, many other studies in the field have approached the work in a different way whereby the dancing is done in response to a research study that has been developed. In the latter case, the research team might have more control over things like class frequency or content and the study is often set up in a way that best helps the team answer their research questions. The present study used methods that allowed the research team to observe and analyse an already existing artistic project and in doing so has produced findings that are different to many other studies in the field. However, it is not possible to discern exactly why our results differed from other studies at this stage and thus whether other studies would have differing results if they had followed the methods used in the present study. The only way to determine this would be to repeat the study multiple times using various dance forms and class frequencies.

Finally, it should be pointed out that although the present study did not see any significant changes to gait variability or balance confidence, the ballet classes may provide other social, emotional, and psychological benefit that would impact upon daily activities and participation (Houston, 2015).

With regards to study limitations, the researchers in the present study participated in the weekly ballet sessions. While they were able to gather rich data about the participant experience, the study did not follow a blinded design. As such, care was taken to apply ID numbers to avoid any potential bias.

Some of the questions within the Activities Specific Balance Confidence (ABC) Scale caused confusion for a few participants as they felt that their answers would differ depending on the situation and environment they were placed in. When participants were unclear about certain questions, they were able talk to the researcher to gain further clarity before providing the most appropriate answer. Although instructions were provided that asked participants to rate their scores on a 100% scale in increments of ten, multiple participants consistently recorded their scores in increments of five. Scores were always rounded down in this situation.

In the case of missing data, if participants were missing more than a quarter of the questions, a total value of 999 was inputted into the SPSS data file. If less than a quarter of questions were missing, the total score was divided by the number of questions completed, and then multiplied by the total amount of questions in the scale.

Conclusion

The results from the present study demonstrate no significant changes in step and stride variability or balance confidence after 12 months of weekly ballet classes for a group of people with Parkinson’s. Future research should continue to assess potential changes in dynamic stability and the impact upon daily activities as a result of participation in different protocols of ballet-based classes. For instance, assessing these changes in an intervention protocol with increased frequencies of classes per week would help researchers identify optimal training frequency. Furthermore, applying the principle of overload may help to avoid physical plateau over a longer period of time. Future research also needs to look at the mechanisms of change with regards to ballet for people with Parkinson's. Through understanding the effects of specific movements and how frequently participants need to practice those movements, we may be better able to make clearer recommendations about dance for people with Parkinson's. Future research in the field should also look at the psychosocial effects of dance interventions and substantiate the conclusions we are making about dance having a significant positive impact upon people with Parkinson's.

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Competing Interest Statement

There are no financial disclosures or personal relationships with other people or organizations that could inappropriately influence (bias) this piece of work.

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