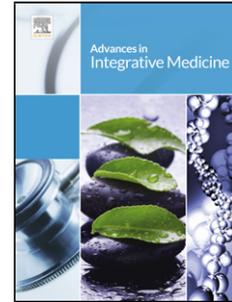# Accepted Manuscript

1   **Improvements in Balance and Gait Speed after a 12 Week Dance Intervention for**

2   **Parkinson's Disease.**

3   Karolina A. Bearss, B, K. A (M.Sc)[1,2,4], Katherine C. McDonald, M, K.C (B.A)[2]

4   Rachel J. Bar, B, R.J (M.A)[5,6]

5   Joseph F.X. DeSouza, D, J.F.X (Ph.D)[1,2,3,4,7]

6   Centre for Vision Research[1], Departments of Psychology[2] & Biology[3], Neuroscience Graduate Diploma

7   Program and Interdisciplinary Studies[4], Canada's National Ballet School[5], Ryerson University[6],

8   Canadian Action and Perception Network (CAPnet), York University, Multisensory Neuroscience

9   Laboratory[7]

10   **Corresponding Author:**
11   Karolina A Bearss
12   Centre for Vision Research, York University
13   4700 Keele St., Toronto, ON, Canada, M3P 1P3
14   phone: 416 736 2100
15   email: skrzypek@yorku.ca
16

17   **Word count abstract (250 words max) = 166**
18   **Brief Report Text (1500 words max) = 1016**
19   **Tables and Figures (max 5) = 2**
20   **References (10 Max) = 10**
21
22   **Running Title**: IMPROVEMENTS IN BALANCE AND GAIT SPEED
23
24   **Key words**: dance for Parkinson's Disease; quality of life; motor symptoms

25   **CONFLICT OF INTEREST:** none.
26

Abstract

37

38   Preliminary research[2-7] suggests dance is beneficial for people with Parkinson's disease (PD) and

39   can serve to compliment traditional medical treatments. There are many types of dance classes[4-6]

40   however, research on Dance for PD® (DfPD®) model has shown rapid growth in participant

41   attendance and interest over time[2-3]. In addition, unlike other studies where the description of the

42   dance program has been rather vague, the DfPD® model has clear principles and a specific

43   structure. The DfPD® model was developed in collaboration with the Brooklyn Parkinson Group

44   and Mark Morris Dance Group, these dance classes are specifically designed to address

45   symptom-specific concerns relating to PD. For researchers, this model allows easier replication

46   to examine effects than a dance program that is not widely disseminated or as specific and the

47   DfPD® model was implemented within this study for these reasons. What remains unknown, is

48   the specific length of dance intervention required, measured in weeks and hours, until

49   improvements are seen in motor impairments and quality of life (QoL) in PD.

50   **OBJECTIVE**

51   We aimed to replicate and extend previous findings[2-3] where enhancements were shown on short-

52   term motor (1-day)[3] and quality of life using the DfPD® model. Here we conducted a 12-week

53   pilot study using the DfPD® model, where these enhancements were observed in 34% less dance

54   intervention duration within this model (15 hours), than the other two aforementioned studies (8-

55   months[3] & 17-months[2]).

56   **DESIGN**

57   In this quasi-experimental, non-controlled study, 9 participants completed 2 motor and QoL

58   questionnaires before and after the second and twelfth class at DfPD®.

59   **RESULTS**

60   Results indicated motor improvements for both balance and gait in short-term (1-day) and long-

61   term (12-weeks). No improvements in QoL were observed.

62   **CONCLUSIONS**

63   Participation in DfPD® model dance classes, improved motor symptoms in both short (1-day)

64   and long-term (12-week) durations. Overall, QoL did not change from the second to twelfth

65   week.

66   **Statements of:**

67   **What is already known about this topic:** Existing research has already shown short-term motor

68   and quality of life improvements in PD in 8-months[3] & 17-month[2] trials.

69   **What this paper adds:** An extension to the existing literature on the *required* length of time

70   necessary to see these beneficial impacts within this population. What remains unknown in the

71   literature on this topic, is the *specific length* of dance intervention that is needed, measured in

72   weeks and hours, until initial improvements are seen in both motor and quality of life in PD.

73   **Introduction**

74   Parkinson's Disease (PD) is described is a common hypokinetic movement disorder of

75   the central nervous system primarily associated with dysfunction of the basal ganglia

76   (BG). This subcortical structure plays a prominent role in motor learning, particularly in the late

77   stage of learning where movement sequence retrieval is more implicit and habitual. Difficulty in

78   executing habitual movement is a distinct feature of PD.

79   Levodopa, the primary pharmacological medicine for PD, has multiple limitations in its

80   intervention. Only a few motor symptoms of PD are temporarily treated, there is a decreased

81   efficacy of drug treatment as PD progresses, symptoms become progressively resistant to

82   levodopa[1], non-motor symptoms of PD are ignored, and finally adverse side-effects such as

83   depression, anxiety, hallucinations and dyskinesia arise as a result of levodopa use. Due to these

84   various limitations, research within this field has shifted its attention to other forms of

85   interventions, such as dance therapy, intended to improve daily functioning and quality of life by

86   teaching and training PD patients compensatory movement strategies while providing a positive

87   social atmosphere. Various dance classes have shown to alleviate motor symptoms of people

88   with PD[2-7]. We studied dance classes using the Dance for PD® (DfPD®) model first conceived

89   by Westheimer[2]; this model, a collaboration of the Mark Morris Dance Group (MMDG) and the

90   Brooklyn Parkinson Group (BPG), posits an artistic model in its aims and conception for those

91   with PD (and their caregivers) that has been implemented worldwide. DfPD® classes target PD

92   specific symptoms related to balance, cognition, motor skill, depression and physical confidence.

93   Our study intended to examine the shortest dance session (12-weeks; 15 hours) in novel PD-

94   dancers compared to studies of 8-months[3] and 17-months[2]. Westheimer[1] employed a similar

95   dance program, over 17-months, and reported long-term QoL benefits. Heiberger et al.,[3]

96   employed an 8-month dance program to examine short-term effects on motor control after one

97   dance class and studied long-term effects of QoL.

98   This study aimed to replicate short-term (1-day) motor improvements[3] and extend

99   research to examine long-term motor (12-week) and QoL measurements (at weeks 2 and 12)

100   following participation in weekly DfPD® classes. Unlike previous DfPD® studies[2-3] that

101   reported findings after 8-months[3] and 17-months[2], the present study looked at the effects of a

102   dance program that is on average 34% shorter in dance intervention duration. We hypothesized,

103   short-term (1-day) and long-term (12-week, 15 hours) motor improvements and increases in QoL

104   scores from baseline (week 2) to week 12.

105
106   **Methods**

107   *Participants*

108   Fourteen individuals initially volunteered for the study; five did not complete the entire

109   protocol, before and after class testing during weeks 2-12, due to personal reasons and absences.

110   Thus, a total of nine PD participants volunteered from a new Dancing with Parkinson's Program

111   at Canada's National Ballet School (NBS); H&Y range = asymptomatic to severe (0-4), $M_{H\&Y}$ =

112   0.8 (M_{age} = 67.78 ± 6.14yr; n_{Males} = 5; average length of disease diagnosis = 5.56 years; range =

113   0-17 years). Written informed consent was obtained using an approved protocol from York

114   University's Ethics Board (2013-211).

115   *Measures*

116   The Berg Balance Scale (BBS)[8,9] (n = 5) and the Timed Up and Go (TUG) (n = 5) test

117   were employed for this study as a measure of motor performance. The BBS is comprised of 14

118   tasks, measuring different functions of balance and posture that are common to daily living. Each

119   task is judged on an ordinal scale ranging from 0 to 4 (La Porta et al., 2012), and evaluated as

120   either a factor of time to complete, or quality of execution. With this measure, a total score of 56

121   reflects perfect balance. TUG is a timed measurement (in seconds) of movement sequencing,

122   gait, and balance control. This test requires a participant, on request, to rise from a seated

123   position, walk 3 meters (indicated by a marking on the floor), turn around, return to the seat, and

124   sit back down. Two QoL questionnaires (n = 9) were administered: the Quality of Life Scale

125   (QoLS) from Oregon Health and Sciences University and a post-dance class questionnaire of

126   wellbeing developed by Westheimer[2] and Heiberger et al[3] was used. Repeated-measure

127   comparisons for the BBS and QoLS were analyzed using the Wilcoxon sign-ranked test. TUG

128   scores were analyzed using a paired samples *t*-test.

129   *Procedure*

130   Motor assessments (BBS and TUG) were conducted on two separate occasions; the class

131   of week 2 (class 2) and the class of week 12 (class 12). On both occasions participants were

132   tested before and after the class. Testing was conducted at week 2, instead of week 1 as

133   attendance is higher after the initial class as most participants are returning from their summer

134   vacations and the study is explained in class 1, causing it to be of shorter duration in comparison

135   to the remaining classes in weeks 2 – 12. For the QoLS, questions 17 and 18 appeared on the

136   questionnaire at week 12. A weekly 75-minute dance class for 12-weeks was instructed by two

137   NBS DfPD® trained faculty. Classes commenced with a seated warm-up on chairs, followed by

138   "barre" work, and ended with dancing across the floor exercises, choreography was also learned

139   each week with the aim to have a performance on week 12 (**Table 1**).

Results

141   The results for BBS showed long-term improvements (12-weeks) on balance scores for

142   those measured after week 2 (n = 5; *Mdn* = 50) and after week 12 (*Mdn* = 53.5), *Z* = -2.02, *p* =

143   .022, *r* = .91, one-tailed (**Figure 1A**); the same was found for those measured before week 12 (n

144   = 7; *Mdn* = 53) and after week 12 (*Mdn* = 54) *Z* = -2.39, *p* = .009, *r* = .90, one-tailed (**Figure

145   1B**). A significant decrease in time to complete the TUG was also found when comparing the

146   measures after week 2 (*M* = 10.2, *SEM* = .93) and after week 12 (*M* = 8.18, *SEM* = .47) *t*(4) =

147   2.25, *p* =.044, *r* = .75, one-tailed (**Figure 1C**). No significant decrease in time was found for

148   those performing the TUG before (*M* = 9.26, *SEM* = .67) and after week 12 (*M* = 8.85, *SEM* =

149   .54), *t*(6) = .90, *p* = .20, one-tailed.

150   The total score for the QoL (n = 9) showed no significant change from the end of week 2

151   (*Mdn* = 85.6) to week 12 (*Mdn* = 87) *Z* = -0.14, *p* = .45, one-tailed. However, when assessing

152   each item individually, there were significant changes for item 3 (rating relationships with

153   parents, siblings, and other relatives - communicating, visiting, helping) and for item 9 (learning

154   - attending school, improving understanding, getting additional knowledge). Item 3 resulted in a

155   significant reduction in score from class 2 (Mdn = 6.00) to class 12 (Mdn = 5.00) Z = -1.90, p =

156   029, r = .63, one-tailed, while item 9 significantly increased from class 2 (Mdn = 5.00) to class

157   12 (Mdn = 5.00) Z = -2.449, p = .007, r = .81, one-tailed.

158   **Discussion**

159   With BBS and QoL, an increase in score represents enhanced balance and enhanced QoL,

160   respectively. The TUG task is measured in seconds, and a decrease in time to complete the TUG

161   indicates an improvement of gait speed and ambulation. As hypothesized, results revealed, for

162   the first time, long-term changes in 15 hours of participation in a 12-week DfPD® program in

163   both balance performance and gait speed, as BBS numbers increased and time to complete TUG

164   decreased at week 12 in comparison to week 2. These findings replicate Heiberger's[3] short-term

165   improvements (1-day) in balance when evaluated before and after a class. Unlike previous

166   studies[2-3] where QoLS were provided once, our study performed a before and after sampling and

167   found that there were no improvements from week 2 to week 12 which may be due to the fact

168   that our QoL baseline scores were measured at week 2, and thus the participants have already

169   been exposed to the group and the model itself which may have increased their QoL scores.

170   Follow-up studies should measure QoL prior to registration before having experience with the

171   DfPD® program and the research being conducted. Results in our study add to those in

172   Westheimer et al (2015)[7] 20 hour dance study, where motor improvements, in balance and gait,

173   are seen as early as 15 hours into dance class. In summary, although long-term changes in

174   balance and gait were found, a parallel degree of change for overall QoLS scores did not occur

175   from week 2 to week 12. QoLS may have potentially already increased after just two weeks of

176   dance class, what is more important for future studies is to uncover the mechanisms[10], such as

177   neural or structural changes, that underlie these behavioural changes.

178

181

182
183   **Author Roles**. At the end of the manuscript, all authors must be listed, along with their specific
184   roles in the project and manuscript preparation. These should include but not be restricted to:
185
186   1.Research project: A. Conception – JFXD, KM, RJB; B. Organization – JFXD, KM, RJB;
187   C. Execution – JFXD, KM, RJB
188   2. Statistical Analysis: A. Design – JFXD, KM; B. Execution – JFXD, KM;   C. Review
189   and Critique – JFXD, KM, KB;
190   3. Manuscript Preparation: A. Writing of the first draft – JFXD, KB, KM;   B. Review and
191   Critique – JFXD, KB, KM, RJB
192

193
194   References

195   1. Hely MA, Fung VSC, & Morris JGL. Treatment of Parkinson's disease. Journal of Clinical

196   Neuroscience 2000; 7: 484-494.

197   2. Westheimer, O. Why dance for Parkinson's disease. Topics in Geriatric Rehabilitation 2008;

198   24: 127-140.

199   3. Heiberger L, Maurer C, Amtage F, et al. Impact of a weekly dance class on the functional

200   mobility and on the quality of life of individuals with Parkinson's disease. *Front Aging*

201   *Neurosci* 2011; 3: 1–15.

202   4. Houston S, & McGill A. A mixed-methods study into ballet for people living with

203   Parkinson's. *Arts Health* 2013; 5: 103-119.

204   5. Mandelbaum R, & Lo A. C. Examining dance as an intervention in Parkinson's disease: A

205   systematic review. *American Journal of Dance Therapy* 2014; 36: 160-175.

206   6. Volpe D, Signorini M, Marchetto A, Lynch T, & Morris M. E. A comparison of Irish set

207   dancing and exercises for people with Parkinson's disease: A phase II feasibility study. *BMC*

208   *Geriatr* 2013; 13: 1-6.

209   7. Westheimer O, McRae C, Henchcliffe C, Fesharaki A, Glazman S, Ene H, & Bodis-Wollner

210   I. Dance for PD: a preliminary investigation of effects on motor function and quality of life

211   among persons with Parkinson's disease (PD). *J Neural Transm* 2015; 122: 1263-1270.

212   8. Qutubuddin A. A, Pegg P. O, Cifu D. X, Brown R, McNamee S, & Carne W. Validating the

213   Berg balance scale for patients with Parkinson's disease: A key to rehabilitation evaluation.

214   *Arch Phys Med Rehabil* 2005; 86: 789-792.

215   9. La Porta F, Caselli S, Susassi S, Cavallini P, Tennant A, & Franceschini M. Is the Berg

216   balance scale an internally valid and reliable measure of balance across different etiologies in

217   neurorehabilitation? A revisited Rasch analysis study. *Arch Phys Med Rehabil* 2012*;* 93:

218   1209-1216.

219   10. Bar, R.J., & DeSouza J.F.X. Tracking plasticity: Effects of long-term rehearsal in experts

220   encoding music to movement. *PLoS One* 2016; 11: e0147731.

221
222

223   **Questionnaire A: Adapted Oregon Quality of Life Scale Questionnaire (QOLS):**

1. Material comforts - home, food, conveniences, financial security.

2. Health - being physically fit and vigorous.

3. Relationships with parents, siblings, and other relatives - communicating, visiting, helping.

4. Having and rearing children.

5. Close relationships with spouse or significant other.

6. Close friends.

7. Helping and encouraging others, volunteering, giving advice.

8. Participating in organizations and public affairs.

9. Learning - attending school, improving understanding, getting additional knowledge.

10. Understanding yourself - knowing your assets and limitations - knowing what life is about

11. Work- job or in home.

12. Expressing yourself creatively.

13. Socializing - meeting other people, doing things, parties, etc.

14. Reading, listening to music, or observing entertainment.

15. Participating in active recreation.

16. Independence, doing for yourself.

17. Moving around - walking, standing up

18. Have any of the numbered items, 1-17, changed for the better as a result of attending the Dance for PD classes? If so, please indicate which number(s)

224

225   **Post-Class Questionnaire of Well-being:**

226   **Please read each item and circle the answer that best describes how you feel.**
227   A. How is your body feeling after the dance class?
228   1. Much better
229   2. Better
230   3. The same
231   4. Worse
232   5. Much Worse

233
234   B. How is your state of mind after the dance class?
235   1. Much better
236   2. Better
237   3. The same
238   4. Worse
239   5. Much Worse

240
241   C. Do you feel that the consequences of the dance class impact your quality of life on a daily
242   basis?   Yes/No

243
244   D. If yes, how long do you feel that the impact lasts?
245   1. Minutes
246   2. Hours
247   3. Days
248   4. Weeks
249
250   E. How is your mobility after dance class?
251   1. Much better
252   2. Better
253   3. The same
254   4. Worse
255   5. Much Worse
256
257   F. What do you believe specifically makes this dance class work for you?

258   _____

259   _____

260
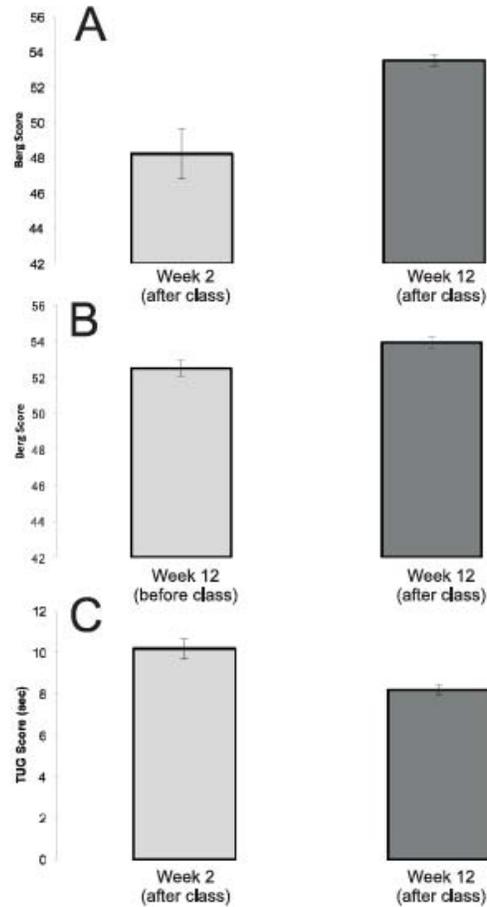261   G. What brings you back to class each week?

262   _____

263   _____

264

265
266

267

Figure 1: A. Parkinson's participants' mean scores for the BBS questionnaire performed after week 2 and week 12 (n=5; Wilcoxon Sign-Ranked test $p<.05$, one-tailed). Error bars represent standard error of the mean (*SEM*) for all bar graphs. **B.** Parkinson's participants' mean scores for the BBS questionnaire performed before and after the last dance class (n=7; Wilcoxon Sign-Ranked test $p<.05$, one-tailed). **C.** Parkinson's participants' mean scores for the TUG test performed after week 2 and week 12 (n=5; paired samples t-test $p<.05$, one-tailed).

268

Table 1: Sample exercises featured in the dance class at NBS:

Exercise	Description	Purpose
Danced name introduction	Stating your name with a corresponding dance movement. The rest of the class first watches before repeating the participants name and movement. Standing or seated.	Feeling welcomed and welcoming everyone in the class. Practicing skills of choreographing on the spot.
Tendus	Pressing the feet along the floor until the leg is fully extended. Arms follow a similar extension motion. Seated.	Warming up the feet and lower leg, while working on strengthening the core.
Shuffle dance	A series of shuffles, stamps, and ankle inversions. Seated.	Facilitating flexibility and mobility in the ankles and knees.
Magic dance	Dancing with an imaginary ball and scarf, while exploring a range of motion. Seated.	An opportunity for vivid imagery and creative interpretation.
Rainfall cannon	Simulating the sounds of an approaching rainstorm using various body parts as percussion instruments. Seated.	Practicing movement initiation by waiting to execute a movement in proper sequence.
Winning the poker game	Rising slowing from a chair while moving in a celebratory manner.	Practicing rising from a seated position in a safe manner.
Painter and Sculptor mirrored pairs	A paired improvisation dance, done face to face. One partner would lead while the other mirrored their painting motion. This dance	Mirroring a partner in a detailed fashion, and practicing creative movement initiation by

	finished with a series of intertwined sculpture-like poses. Seated and standing aspects.	improvising and developing unique poses.
Pliés in parallel and second position	Holding on to the back of a chair, pliés (bending of the knees) and rises were done in parallel (feet together) and apart. Standing.	Developing strength and balance while standing and increasing range of motion in the legs.
Lunging side to side	While holding onto the back of the chair, transferring weight from side to side with legs in a wide pronated position and "brandishing a fist" at a neighbouring participant. Standing.	Finding a core centre for balance by lunging off balance and returning to a central position.
Waltz	Waltz step performed first on the spot and the travelling. Standing.	Safely dancing through space, and physically embodying the triplet rhythm of a waltz.
Shy to confident shuffle dance	A standing variation of the seated shuffle dance, where the movements are done first in a demur and small manner, but gradually increase in confidence until they are gregariously expressed.	A fun way of practicing moving with confidence and with clear intention.
The "Showdown Hoedown" dance	Approximately a 2 minute choreography done facing a partner, first dancing as advisories in the "showdown" and then together as companions in the "hoedown." Standing.	Challenging participants to recall a lengthy piece of choreography with multiple sections and changes of direction

- Pilot study, short-term motor improvements from dance in people with Parkinson's Disease
- BBS and TUG motor measurements, improved after 12-week dance program
- Benefits of dance arise in only 15 hour participation in Dance with Parkinson's programme