GAMES FOR HEALTH JOURNAL: Research, Development, and Clinical Applications
Volume 2, Number 4, 2013

DOI: 10.1089/g4h.2013.0011

# Perceptions of a Videogame-Based Dance Exercise Program Among Individuals with Parkinson's Disease

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## Abstract

***Objective:*** Physical therapy, including exercise, improves gait and quality of life in Parkinson's disease (PD). Many programs promoting physical activity have generated significant short-term gains, but adherence has been a problem. A recent evidence-based analysis of clinical trials using physical therapy in PD patients produced four key treatment recommendations: cognitive movement strategies, physical capacity, balance training, and cueing. We have attempted to incorporate all four of these features together through a dance exercise program using the dance videogame "Dance Dance Revolution" (DDR) (Konami Digital Entertainment, El Segundo, CA).
***Subjects and Methods:*** Sixteen medically stable participants with mild to moderate PD were given the opportunity to try DDR with supervision by a research staff member. Feedback about the advantages and disadvantages of DDR as a form of physical activity was elicited through focus groups using the nominal group technique.
***Results:*** Of 21 advantages and 17 disadvantages elicited, the most frequently cited advantages were "fun" and "easy to use," followed by "improves balance or coordination," "challenging," and "full body aerobic activity." Common concerns were the distracting or confusing interface, cost, and possible technical issues.
***Discussion:*** Interactive dance exercise was appealing to participants with PD and may help promote adherence to physical activity. Concerns regarding familiarity with the technology may be addressed with simplification of the interface or additional training for participants. Results support a larger longitudinal study of DDR in PD.

## Introduction

Parkinson's disease (PD) is a neurodegenerative condition affecting over 1 million Americans.[1] PD is characterized by tremor, rigid tone, impaired balance, and slowing and/or lack of movement (freezing). Physical activity has been shown to improve gait and quality of life, as well as provide short-term gains, but adherence to physical activity programs is a problem.[2] In PD, additional hurdles to increasing physical activity include cognitive dysfunction, apathy, and impaired mobility and balance. A recent evidence-based analysis of clinical trials using physical therapy in PD produced four key treatment recommendations for a successful program: Cognitive movement strategies, physical capacity, balance training, and cueing.[3] There has yet to be a program that incorporates all of these features while providing rewarding stimuli to promote adherence. Our objective was to explore the utility of a videogame-based dance exercise program in PD, as it may address each of these key areas (Table 1).

Videogames have become a widespread form of recreation, with newer games requiring whole body activity. "Dance Dance Revolution" (DDR) (Konami Digital Entertainment, El Segundo, CA), a dance-based videogame, combines the recreational nature of a videogame with the benefits of dance, such as increased balance, coordination, and strength.[4] Adherence to dance-based aerobic exercise programs has been relatively high, with low injury rates.[4] Because dance-based videogames are intentionally engaging and give rapid feedback and rewards, adherence to physical activity may be promoted. Additionally, apathy may be addressed by associating physical activity with rewarding stimuli. Up to 80% of dopamine neurons in the brain can be activated by a reward-based activity. This release of dopamine may result in improved motor performance, particularly in PD, a condition characterized by dopaminergic deficiency.[5]

The primary aim of this study was to investigate perceived advantages and disadvantages of a dance-based videogame among a small number of participants diagnosed with PD.

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Table 1. How "Dance Dance Revolution" May Address Recommendations for Physical Therapy in Parkinson's Disease

| *Recommendation*[3] | *DDR component* |
|---|---|
| Cueing strategies to improve gait | Audio cues of steps synchronize to music; visual cues of arrows scroll to the top of the screen for each step. |
| Cognitive movement strategies to improve transfers | Individual steps are progressively combined with cues to form more complex dance maneuvers. |
| Exercises to improve balance | Participants are upright, stepping and shifting weight throughout DDR, being spotted and building confidence. |
| Training of joint mobility and muscle power to improve physical capacity | A self-paced gradual increase in speed and intensity of dance maneuvers requiring increased joint mobility |

DDR, "Dance Dance Revolution."

Our exploratory aim was to determine the feasibility of DDR in the PD population in order to promote physical activity.

## Subjects and Methods

### *Participants*

Subjects, in groups of up to six, received an orientation to the dance system and observed a demonstration by research staff. Each participant was then given the opportunity to try DDR under direct supervision of a research staff member (Fig. 1). Participant feedback was collected through focus groups using the nominal group technique (NGT) as described in the outcomes section below. The rights of human subjects were maintained, and the study was approved by the University of Pittsburgh Institutional Review Board. Participants were recruited from tertiary referral centers for movement disorder clinics and an institutional registry of patients with PD. Participants were provided with parking and light refreshments. No monetary compensation was given. Informed consent was obtained.

Sixteen medically stable PD patients were enrolled. Inclusion criteria were as follows: Meeting the United Kingdom PD Society Brain Bank Clinical Criteria[6]; 40 years of age or older; Hoehn and Yahr score of $\leq 3$; and not currently participating in regular physical exercise. Regular physical exercise was defined as at least 30 minutes of physical activity three times per week associated with increased heart rate. Patients were required to be capable of walking ½ mile and climbing one flight of stairs without an assistive device or help from another person. Patients were excluded if they had the following: A preexisting diagnosis of osteoporosis; a history of bone fracture in the absence of major trauma or high-intensity sports after 40 years of age; vertebral compression fracture; recurrent falls; weight-bearing pain that limits physical activity; current or past lung, cardiovascular, neurological, or neuromuscular diseases other than PD; radiation or chemotherapy for cancer; nonelective hospitalization in the last 6 months; or any other medical condition or physical limitation that could increase the risk of injury from physical activity, including reduced vision or hearing.

### *Intervention*

The interactive videogame DDR includes a 3-foot×3-foot mat with 1-foot squares marked by four arrows designating the directions forward, backward, left, and right. The monitor instructs the participant by a system of scrolling arrows of four types (up, down, left, and right), which arise from the bottom to the top of the screen. As the arrows scroll up to the top of the screen, they cross over a set of four arrow silhouettes (up, down, left, and right). The participant's goal is to step on the arrow on the mat corresponding to the scrolling arrow as it crosses its respective silhouette. The steps are synchronized to participant-chosen music and increase in complexity and speed as game skills are mastered. After each dance or lesson (about 90 seconds), the participant is given feedback on the number of correct steps with an overall letter grade. A letter grade, ranging from A to E, is assigned based on the number of correct steps, how well timed those steps are, and the complexity of the given song. As dance performance improves, the grade improves, and new songs (of increasing complexity) are offered.

### *Assessment*

Baseline characteristics of participants were measured including age, sex, and scores on the Hoehn and Yahr scale, the Unified Parkinson Disease Rating Scale, Self-Efficacy for Exercise scale, and Activities-specific Balance and Confidence scale. The Hoehn and Yahr scale provided a general estimate of motor impairment in PD participants.[7] The Unified Parkinson Disease Rating Scale provided a baseline measure of PD-related disability and impairment.[8] Self-Efficacy for Exercise measured efficacy and expectations related to aerobic exercise and helped identify participants with low self-efficacy expectations[9]; a score of 0 represented not at all confident, and a score of 10 represented highly confident. The Activities-specific Balance and Confidence scale measured balance confidence of 16 different activities, incorporating static, dynamic, proactive, and reactive balance[10]; in this scale, 0% represented no confidence, and 100% represented complete confidence. The Borg scale was used to measure perceived exertion while using DDR.[11]

Participant feedback was scored using the NGT, which is a group technique that takes advantage of pooled judgment.[12] This standardized method combines individual reflection and creativity, information sharing, and group prioritization. The NGT is based on research that finds this process superior to other group problem identification methods in terms of generating a higher quantity, quality, and distribution of critical problem dimensions for problem exploration tasks.[12] NGT involves five stages: Introduction and explanation, silent generation of ideas, sharing ideas, group discussion, and voting and ranking.[12] Prior to beginning the NGT, a trained moderator gave an opening statement to clarify group objectives, to explain the role of participants, and to provide a sense of how the group's output would be used. The objective was to identify advantages and disadvantages of interactive video dance as a form of physical activity for PD patients.

During the first step (silent generation of ideas), participants were asked to write up to five advantages (aspects that


**FIG. 1.** In "Dance Dance Revolution," participants dance on a 3-foot×3-foot mat with squares marked by arrows: forward, backward, left, and right. The monitor instructs the dancer by a system of scrolling arrows (up, down, left, and right). Steps are synchronized to music chosen by the participant and become more complex and faster as movements improve.

met participant's interests or needs) and five disadvantages (possible barriers to performance or adherence) of dance-based videogames as a form of exercise. Next, in a round-robin fashion, ideas were shared by each participant and recorded by a staff member. After ideas were recorded, participants were invited to seek verbal explanation or further details about any of the ideas. The last step (voting and ranking) involved prioritizing the recorded ideas in relation to the original question to determine the overall relative importance of individual items. We held NGT groups until saturation of ideas was reached, defined as when no new ideas for advantages or disadvantages were generated.

### *Data reduction and analysis*

Descriptive techniques (mean, standard deviation, and percentage prevalence) were used to characterize the sample. For NGT, after written individual responses were collected, each group generated a consolidated list of ideas, and each participant ranked the top five advantages and disadvantages. As per NGT protocol, the top idea from each participant received 5 points, the next 4 points, and so forth. Advantages and disadvantages were classified into categories by a blinded investigator. In cases of divergence, agreement was reached through open discussion. Priorities were summarized by group. Frequency of an item among the three NGT groups was recorded.

## Results

Participant characteristics are summarized in Table 2. All participants reported prior periods of physical activity in their lifetime, but not engaging in any currently. The most common activities were jogging, swimming, bicycling, skating, walking, and yard work. Eight participants had prior experience with videogames.

NGT elicited 21 advantages and 17 disadvantages among individual participants. The top scores are summarized in Table 3. The most frequently cited advantages were "fun" and "easy to use," followed by "improves balance or coordination," "challenging," and "full body aerobic activity." Common concerns were the distracting or confusing interface, the cost, the limited range of movements, the potential for falls, and possible technical issues.

For all participants, the Borg scale (0–10) for pain was 0, and that for distress and fear was $\leq 3$. Discomfort was 0 for all but one participant, who rated it a 3. Perceived exertion was

Table 2. Characteristics of Participants ($N=16$)

| *Baseline characteristic* | *Mean (SD)* |
|---|---|
| Age (years) | 63.1 (9.8) |
| Number of women | 5/16 |
| Hoehn and Yahr scale | ~2 |
| UPDRS-III | 8.6 (5.1) |
| UPDRS total | 32.3 (16.0) |
| SEE (1–10) | 7.6 (2.4) |
| ABC (1–100) | 73.3 (26.4) |

ABC, Activities-specific Balance and Confidence; SD, standard deviation; SEE, Self-Efficacy for Exercise; UPDRS, Unified Parkinson Disease Rating Scale.

1.1 (0.8). There were no reports of loss of balance or need to prevent a fall.

## Discussion

The results of this case series provide suggestive evidence that DDR is well tolerated, fun, easy to use, and perceived to be of benefit in PD participants. Common concerns included a distracting interface and financial expense. Reports of fear, distress, or discomfort were minimal. There was no report of pain or loss of balance. The fact that eight participants had prior experience with videogames suggests that a significant proportion of this age group is familiar with videogames, which may contribute to openness to such interventions.

Activities such as dance-based videogames are emerging as a popular way to exercise[13] and may be relevant to PD patients. In particular, this activity meets all four of the key treatment recommendations for physical therapy in this patient population (Table 1). To our knowledge, this is the first study to report feedback from PD patients about an interactive videogame. Our findings are similar to those in a study of postmenopausal women, which showed that DDR can improve both motor skills and cognition.[13] Virtual reality for gait training has also been reported in the PD population.[14] However, although virtual reality would need to be used in a controlled physical therapy environment, video-dance exercise programs such as DDR may be more accessible to the general PD population and could be used at home.

Table 3. Highest Scores for Advantages and Disadvantages

| | *Total* (n=*16*) |
|---|---|
| Advantages | |
| Fun | 33 |
| Easy to use | 27 |
| Improves balance or coordination | 24 |
| Challenging | 24 |
| Full-body aerobic activity | 23 |
| Disadvantages | |
| Distracting or confusing interface | 41 |
| Financial cost | 31 |
| Limited range of movements | 16 |
| Cannot customize game display | 15 |
| Possible falls | 14 |
| Did not like available music | 14 |

The strengths of our study include the enrollment of a well-characterized population, participants with PD, for which little is known about dance exercise interventions and the use of a structured technique to assess participants' preferences. Our study does have limitations. Sample size was small, and perceptions after a single exposure to DDR may not reflect attitudes after further DDR use. It is possible that some of the perceptions expressed were influenced by socioeconomic status or ethnicity. Additionally, the feasibility of one-time use of DDR cannot be extrapolated to feasibility over longitudinal situations. Participants were volunteers with mild to moderate PD and may have had a more positive attitude than the general PD population. Attitudes of other populations, such as those with more advanced PD or those with comorbid health conditions, are still unknown and should be addressed in further studies. Concerns regarding technical competence among participants may indicate that the interface should be simplified, or that participants need training to become familiar with the technology. Although the Self-Efficacy for Exercise scale and the Borg scale have been shown to be valid and reliable in older adults and healthy individuals, respectively, their use in the PD population has not been studied.

The interactive environment of DDR provides a novel experience for the dopamine-based reward pathways in the brain. In addition to the cognitive and physical benefits perceived while participating in DDR, the transient increase in dopamine may result in improved motor performance even after the exercise intervention is completed.[15] Given our findings that DDR is enjoyable, thus increasing the likelihood of adherence to this physical activity, further studies are needed to assess the long-term benefits of this form of exercise. Additionally, exploration into the use of DDR as a complement to virtual reality training may be warranted.

## Conclusions

Interactive videogames that promote physical activity may be beneficial and appealing forms of exercise for the PD population. Our findings suggest that DDR is feasible in PD and that such an intervention may be well suited to address the needs of this population. Our data support further clinical trials of this novel form of exercise to assess adherence, safety, and health effects.

## Acknowledgments

This work was funded by grants P30 AG-024826 and 1K23 NS070867 from the National Institutes of Health.

## Author Disclosure Statement

No competing financial interests exist.

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