Exploring the Impacts of a Group Motion-Based Technology Intervention for People with Cognitive Impairment

Erica Dove[1,2], Rosalie Wang[1,2], Karl Zabjek[1], Arlene Astell[1,2]

[1]*Rehabilitation Sciences Institute, University of Toronto,* [2]*Toronto Rehab, University Health Network*

INTRODUCTION

Falls are the third cause of chronic disability worldwide [1], with older adults experiencing the greatest number of fatal falls [2]. However, people with cognitive impairment (PwCI: e.g. dementia, Mild Cognitive Impairment [MCI]) experience roughly twice the incidence of falls compared to older people without cognitive impairment [3]. As such, there is a need for interventions that address factors increasing fall risk among PwCI, such as balance impairments [4], a fear of falling or lack of movement confidence [5] and altered cognitive function [6]. Exercise can benefit PwCI, particularly with regards to improving balance [7], reducing fear of falling [8], and promoting cognitive activity [9]. For example, [8] demonstrated a reduction in fear of falling after PwCI participated in a 6-month exercise intervention. However, there are problems with adherence to exercise programs for PwCI given that many exercise programs offered to this population are inaccessible, passive, and unengaging [10,11]. Motion-based technology (MBT: e.g. Xbox Kinect), a type of technology that relies on bodily motions to control actions on a screen, is increasingly being explored to encourage exercise participation among many groups (e.g. people with stroke [12]), including PwCI [13]. Indeed, PwCI can learn to use MBTs and enjoy doing so [14]. However, the impacts of using MBT with PwCI on variables including balance, movement confidence, and cognitive function have yet to be determined [15]. This study is examining the impacts of a group MBT intervention on balance, movement confidence, and cognitive function among PwCI. It is hypothesized that the MBT intervention will improve participants' balance, movement confidence, and cognitive function.

METHODS

Study Design

This study is a 1 (group) x 2 (time) within-participants design, with measurement at pre- and post-MBT intervention. The independent variable is time and the dependent variables are balance, movement confidence, and cognitive function.

Participants

Approximately thirty PwCI who speak and understand English, are without visual impairment, and can stand and walk (with or without an assistive device: e.g. walker), are being recruited from four community-based adult day programs in Durham Region, Ontario, Canada. Before taking part in the study, all participants are required to provide informed consent, or substitute decision-maker (SDM) consent plus participant assent.

Intervention

Participants are currently taking part in a 10-week MBT intervention (Xbox Kinect bowling), held in a group setting at four community-based adult day programs. The MBT utilized in the intervention is the Xbox One Kinect (Microsoft Corporation). The Xbox One Kinect was chosen over other commercially available MBTs (e.g. Nintendo Wii) as interaction with this system requires no hand-held device and depends entirely on lifelike movements (e.g. swinging an arm). The commercially available bowling game, offered through the Kinect Sports Rivals package, is being utilized in this study given that the game of bowling is commonly familiar. Intervention sessions are facilitated using errorless learning techniques, including verbal prompts, gesture demonstrations, and physical assistance, developed to teach PwCI to use MBT [16]. During each session, an average of six participants are seated together in a room and each take several bowling turns (Figure 1). That is, while the active player is using the MBT, the rest of the group sits and observes. This continues for the entire duration of each session (60 minutes).

Figure 1. Intervention Setup

Procedures

Potential participants first complete an eligibility screening questionnaire and the Montreal Cognitive Assessment (MoCA) [17] to determine eligibility. The MoCA is scored out of 30 points, with scores of 26 points or higher indicating healthy cognitive function [17]. After establishing eligibility, informed consent is obtained either through the individual or their SDM. Following this, participants complete a demographic questionnaire and the Mini Balance Evaluation Systems Test (Mini-BEST) [18]. The Mini-BEST is scored out of 28 points, with a suggested cut-off score of 20 points for identifying people at risk of falls [19]. After completing the pre-test measures, participants take part in a 10-week, group MBT intervention (Xbox Kinect bowling), held twice per week for 10 weeks (20 sessions). At the start of each session, participant attendance is recorded to keep track of the number of sessions each participant takes part in over the 10-week intervention period. During week one, five, and ten, video recordings of each intervention session are taken to capture participants' physical motions related to movement confidence (e.g. fluency of motion). Directly following the conclusion of the 10-week intervention the Mini-BEST and the MoCA are repeated.

Data Analysis

Data collected from all four adult day programs are being combined for analysis and reporting purposes. Participants are required to attend at least 50 percent of the MBT intervention sessions (i.e. 10 of 20 sessions) to be included in the final analysis.

Quantitative Data (MoCA and Mini-BEST)

First, the means, ranges, and standard deviations of the Mini-BEST and MoCA will be calculated to describe the primary outcomes. Then, quantitative data collected via the Mini-BEST and the MoCA will be compared from pre- to post-MBT intervention using paired t-tests. An ANCOVA with post hoc analyses will also be performed to determine whether the number of intervention sessions attended, current and/or recent rehabilitation service use, and the number of days spent at the day program per week affects these outcomes. These analyses will be conducted using a p-value of <0.05 and a confidence interval of 95 percent.

Video Recorded Data

Video recorded data are being coded using behavioral analysis software [20] to capture potential indicators of movement confidence (e.g. fluency of motion) and how these change over time. Coded data can capture the frequency and duration of events and behaviors, which allows for the extraction of count and percentage data related to movement confidence (e.g. percentage of turns completed confidently). The movement confidence coding scheme has been developed by the authors using information from previous studies examining movement confidence [e.g. 21] and observations from previous work with MBT and PwCI [e.g. 14]. Coding of the video recordings is being undertaken by four independent raters (one rater per site), each of whom is responsible for coding all six video recordings from each data collection site. The entirety of each recorded session is being coded by each rater, with each bowling turn of each participant analyzed. After the coding is complete, coded data from the six sessions will be combined into three respective timepoints: 'start' (T1) = the first two sessions, 'mid-point' (T2) = the two middle sessions, and 'end' (T3) = the last two sessions.

RESULTS

Data collection for this project is currently underway. It is expected that all data collection will be completed by May 2020, with data analysis completed by June 2020 (see Table 1).

Table 1. Study Sites

Study Site #	Number of Participants Recruited	Data Collection Completion Date
Site 1	N=7	November 2019
Site 2	N=10	November 2019
Site 3	N=5	April 2020
Site 4	Not yet recruited	May 2020

Demographic details for participants recruited to date (n=22) are presented below (see Table 2). There is currently an even split between males and females. The average age of the participants is 82.1 years of age, with a range from 68 years to 94 years. The average baseline MoCA score is 12.74 points, demonstrating moderate cognitive impairment. As expected in day program settings, clients are quite diverse with regards to cognitive

functioning, with participants' MoCA scores ranging from as low as 2 points to as high as 25 points. The average baseline Mini-BEST score among the recruited participants to date is 15.11 points. Participants vary greatly with regards to balance, with Mini-BEST scores ranging from as low as 8 points to as high as 21 points. However, all participants' scores suggest the presence of balance impairment. With regards to education, about two thirds of the recruited sample completed high school, with very few completing post-secondary education. Of the recruited participants, 63.6% used mobility devices, which is unsurprising given their age and balance scores. With regards to exercise participation, almost all participants report being physically active, with 22.7% of the recruited sample reporting activity participation 5-7 days per week. This is also unsurprising given that seated exercise classes are offered at each day program on a daily basis. Moreover, most (72.7%) of the recruited participants have previous bowling experience, which is unsurprising given the common familiarity of bowling. Finally, none of the recruited participants have previously used MBT.

Table 2. Participant Demographics

Demographic Variable	Recruited Participants (n=22)
Sex (M/F)	11M (50%), 11F (50%)
Age (years)	82.1 years (range: 68-94 years)
Baseline MoCA (/30)	12.74 points (range: 2-25 points)
Baseline Mini-BEST (/28)	15.11 points (range: 8-21 points)
Highest Education	Less than Grade 12: 6/22 (27.3%) Grade 12: 14/22 (63.6%) More than Grade 12: 2/22 (9.1%)
Mobility Device Use	Yes: 14/22 (63.6%), No: 8/22 (36.4%)
Physical Activity Participation	Very Active: 5/22 (22.7%) Somewhat Active: 9/22 (40.9%) Lightly Active: 7/22 (31.8%) Inactive: 1/22 (4.5%)
Previous Bowling Experience	Yes: 16/22 (72.7%), No: 6/22 (27.3%)
Previous MBT Experience	Yes: 0/22 (0%), No: 22/22 (100%)

DISCUSSION

The purpose of this study is to explore the impacts of a group MBT intervention on balance, movement confidence, and cognitive function among PwCI. This study will answer the question of whether a group MBT intervention has the potential to improve balance, movement confidence, and cognitive function among PwCI who attend community-based adult day programs. To our knowledge, this is the first study in an emerging body of literature on MBTs to investigate these important outcomes. It is anticipated that this research will be relevant to scientific, clinical, and professional audiences. For example, if participants show significant improvements in balance, movement confidence, and cognitive function as a result of partaking in the MBT intervention, there is the potential of MBTs being incorporated into rehabilitation interventions (e.g. fall prevention programs) targeting these outcomes. This is important given that balance [4], movement confidence [5], and cognitive function [6] are risk factors for falls among PwCI. The results of this study should provide further insight regarding the potential impacts of MBT for PwCI, which in turn should stimulate further research of an outcomes-based nature. Additionally, it is anticipated that this study will demonstrate the feasibility of using MBT to deliver task-specific interventions to PwCI, which is relevant given that tasks and goals of importance to PwCI are often used to inform rehabilitation interventions. Importantly, this work can also be used to inform the future development and design of MBT games for PwCI, as commercially available MBT games made to date have not been targeted towards PwCI [22]. Finally, this research aims to advocate for the inclusion of PwCI in rehabilitation science and interventions by demonstrating the ability of PwCI to engage in meaningful activity and by emphasizing the importance of meaningful activity to support a good life for PwCI.

REFERENCES

[1] Hsu, C. L., Nagamatsu, L. S., Davis, J. C., & Liu-Ambrose, T. (2012). Examining the relationship between specific cognitive processes and falls risk in older adults: a systematic review. *Osteoporosis International, 23*(10), 2409-2424. doi:10.1007/s00198-012-1992-z

[2] World Health Organization. (2018). Falls. Retrieved February 13, 2020 from https://www.who.int/news-room/fact-sheets/detail/falls

[3] Shaw, F. E. (2007). Prevention of falls in older people with dementia. *Journal of Neural Transmission, 114*, 1259-1264. doi:0.1007/s00702-007-0741-5

[4] Fernando, E., Fraser, M., Hendriksen, J., Kim, C. H., & Muir-Hunter, S. W. (2017). Risk Factors Associated with Falls in Older Adults with Dementia: A Systematic Review. *Physiotherapy Canada, 69*(2), 161-170. doi:10.3138/ptc.2016-14

[5] Borges, S., Radanovic, M., & Forlenza O. V. (2014). Fear of falling and falls in older adults with mild cognitive impairment and Alzheimer's disease. *Aging, Neuropsychology, and Cognition: A Journal on Normal and Dysfunctional Development, 22*(3), 312-321. doi:10.1080/13825585.2014.933770

[6] Amboni, M., Barone, P., & Hausdorff, J. M. (2013). Cognitive Contributions to Gait and Falls: Evidence and Implications. *Movement Disorders, 28*(11), 1520-1533. doi:10.1002/mds.25674

[7] Lam, F. M., Huang, M. Z., Liao, L. R., Chung, R. C., Kwok, T. C., & Pang, M. Y. (2017). Physical exercise improves strength, balance, mobility, and endurance in people with cognitive impairment and dementia: a systematic review. *Journal of Physiotherapy, 64*(1), 4-15. doi:10.1016/j.jphys.2017.12.00

[8] Taylor, M., Lord, S., Brodaty, H., Kurrle, S., Hamilton, S., Ramsay, E., et al. (2017). A home-based, carer-enhanced exercise program improves balance and falls efficacy in community-dwelling older people with dementia. *International Psychogeriatrics, 29*(1), 81-91. doi:10.1017/S1041610216001629

[9] Öhman, H., Savikko, N., Strandberg, T. E., & Pitkälä, K. H. (2014). Effect of physical exercise on cognitive performance in older adults with mild cognitive impairment or dementia: A systematic review. *Dementia and Geriatric Cognitive Disorders, 38*(5-6), 347-365. doi:10.1159/000365388

[10] Hobson, N., Dupuis, S. L., Giangregorio, L. M., & Middleton, L. E. (2019). Perceived Facilitators and Barriers to Exercise Among Older Adults with Mild Cognitive Impairment and Early Dementia. *Journal of Aging and Physical Activity*, (ePub ahead of print), 1-11. doi:10.1123/japa.2019-0010

[11] Všetečková, J., Deepak-Gopinath, M., Borgstrom, E., Holland, C., Draper, J., Pappas, Y., et al. (2018). Barriers and facilitators to adherence to group exercise in institutionalized older people living with dementia: a systematic review. *European Review of Aging and Physical Activity, 15*(11). doi:10.1186/s11556-018-0200-3

[12] Sin, H., & Lee, G. (2013). Additional virtual reality training using Xbox Kinect in stroke survivors with hemiplegia. *American Journal of Physical Medicine and Rehabilitation, 92*(10), 871-880. doi:10.1097/PHM.0b013e3182a38e40

[13] Dove, E., & Astell, A. J. (2017a). The use of motion-based technology for people living with dementia or mild cognitive impairment: A literature review. *Journal of Medical Internet Research, 19*(1), e3. doi:10.2196/jmir.6518

[14] Dove, E., & Astell, A. J. (2017b). The Kinect Project: Group motion-based gaming for people with dementia. *Dementia, 18*(6), 2189-2205. doi:10.1177/1471301217743575

[15] van Santen, J., Dröes, R-M., Holstege, M., Blanson-Henkemans, B., van Rijn, A., de Vries, R., et al. (2018). Effects of exergaming in people with dementia: Results of a systematic literature review. *Journal of Alzheimer's Disease, 63*(2018), 741-760. doi:10.3233/JAD-170667

[16] Dove, E., & Astell, A. J. (2019). Kinect Project: People with dementia or mild cognitive impairment learning to play group motion-based games. *Alzheimer's & Dementia: Translational Research & Clinical Interventions, 5*, 475-482. doi:10.1016/j.trci.2019.07.008

[17] Nasreddine, Z. S., Phillips N. A., Bedirian, V., Charbonneau, S., Whitehead, V., & Chertkow, H. (2005). The Montreal Cognitive Assessment (MoCA): a brief screening tool for mild cognitive impairment. *Journal of the American Geriatrics Society, 53*, 695-699. doi:10.1111/j.1532-5415.2005.53221.x

[18] Franchignoni, F., Horak, F., Godi, M., Nardone, A., & Giordano, A. (2010). Using psychometric techniques to improve the Balance Evaluation Systems Test: The Mini-BEST. *Journal of Rehabilitation Medicine, 42*, 323–331. doi:10.2340/16501977-0537

[19] Leddy, A. L., Crowner, B. E., & Earhart, G. M. (2011). Utility of the Mini-BESTest, BESTest, and BESTest sections for balance assessments in individuals with Parkinson disease. *Journal of Neurologic Physical Therapy, 35*(2), 90-97. doi:10.1097/NPT.0b013e31821a620c

[20] Noldus Information Technology. (2018). The Observer® XT. Retrieved February 12, 2020 from http://www.noldus.com/human-behavior-research/products/the-observer-xt

[21] Keogh, J. F., Griffin, N. S., & Spector, R. (1981). Observer Perceptions of Movement Confidence. *Research Quarterly for Exercise and Sport, 52*(4), 465–473.

[22] Dove, E., & Astell, A. (2017). Designing Motion-Based Technology for People Living with Dementia. Retrieved February 12, 2020 from https://drive.google.com/file/d/0B3f0GELm2hJ4S1lLWkl3NTZGYWs/view