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The Feasibility of a Novel Dual-Task Exercise Program Which Integrates Balance, Gaze, Mobility and Cognition in Community Dwelling Older Adults: Protocol for a Randomized Clinical Pilot Trial

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Abstract

Background: Mobility limitations and cognitive impairments which are common with ageing often coexist, causing a reduction in the levels of physical and mental activity and are prognostic of future adverse health events and falls. Consequently, multi-task training paradigms that simultaneously address both mobility and cognition benefit healthy ageing are important to consider in rehabilitation as well as primary prevention. Objectives: An exploratory RCT is being conducted to: a) describe the feasibility and acceptability of the study design and process, procedures, resources and management in two game-based dual-task training programs delivered in the community; b) to explore the lived experiences of the study participants who completed their respective exercise programs. A secondary objective is to obtain preliminary data on the therapeutic effectiveness of the two dual-task training programs. Methods: Thirty healthy older community dwelling participants aged 70 - 85 with previous history of falls will be recruited and randomized to either dual-task treadmill walking (experimental group) or dual-task recumbent bicycle (control group). Data analysis: The qualitative data will be analyzed by two investigators using a content analysis approach. For the quantitative data, outcome measures will be collected pre and post intervention and included measures to assess core balance, spatial-temporal gait variables, visual tracking and cognitive function, as well as, balance and gait analysis under dual-task conditions. Discussion:

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This research will demonstrate the feasibility of the dual-task training programs in the community, and demonstrate the system's ability to improve targeted and integrated (dual-task) aspects of balance, mobility, gaze, and cognitive performance. A blended analysis of balance, mobility gaze and cognition will also contribute to a better understanding of the functional consequences of decline in physical and mental skills with age. Trial registration: This pilot clinical trial has been registered at ClinicalTrials.gov Protocol Registration System: NCT01940055.

Keywords

Aging, Spatial-Temporal Gait Variables, Recumbent Bicycle, Dual-Task Training, Visual-Tracking, Executive Cognitive Function

1. Introduction

As people live longer, they become increasingly vulnerable to the effects of sedentary lifestyles and chronic disabilities. For example, balance and cognitive impairments which are common with aging, often coexists causing mobility limitations, and are prognostic of future adverse health events, including falls [1]-[4].

Mobility limitations and increased fall risk can occur due to singular events (e.g. stroke) or can have an insidious onset, with the problem source found in multiple predisposing factors, such as, the gradual age decline of cardiovascular fitness, muscular-skeletal fitness and neural fitness [5] [6]. Each of these systems that underlie mobility has a certain amount of capacity or functional reserve. Walking problems and falls, especially outdoors, become evident when these functional reserves drop below a threshold level and compensatory strategies have failed, or where certain tasks and environmental conditions cannot be avoided [7].

The understanding of the impact of age decline in mobility and cognition is growing. Safe, independent community walking (outdoors and in public) require both mobility skills and cognitive flexibility to address threats to balance while attending to a range of environmental demands, unpredictable conditions, and concurrent cognitive tasks. Several studies have demonstrated that walking while simultaneously performing a cognitive task causes a reduction in gait speed [8] [9] and increases variation of spatial-temporal gait variables [10]-[12]. Studies have demonstrated that the use of these more challenging dual-task conditions for evaluating stability are necessary for the identification of older people who are at an elevated risk of falls [13]-[15]. It is important to note that for older adults, community ambulation is strongly associated with the preservation of skills for independent living, community participation and healthy aging [16] [17].

It is well established that physical activity improves cardiovascular outcomes and reduces risk factors for heart disease and stroke [18]-[20]. A number of studies have evaluated the benefits of exercise programs in community settings [21]-[24]. Results showed that an increase in level of physical activity does translate into improved balance and mobility among community-dwelling older adults. Furthermore, a growing number of studies provide strong evidence for the benefits of physical activity in maintaining some aspects of executive cognitive function [25]-[28]. More recently, studies have described the use and benefits of dual-task training program [29] [30]. In this regard, the application of computer technology provides a number of promising approaches. Anderson-Hanley *et al.*, 2012 [31] showed that coupling recumbent cycling exercise with a virtual reality task did enhance executive function and clinical status more than aerobic exercise alone. Another promising approach involves virtual environments, viewed during treadmill walking. This provides a more ecological and task-orientated approach to dual-task training [32]-[34].

Maximizing participation is also seen as a main goal of interventions. Long-term training programs are often fraught with low compliance and adherence. Maintaining motivation and engagement are thus central to long-term functional success. An emerging methodology is to couple exercise and activities to computer games, making training both an engaging and enjoyable experience. A number of game-based cognitive training applications have been developed to improve specific executive functions such as divided attention, cognitive inhibition, processing speed and working memory [35]-[38]. Recent studies also provide descriptions of the benefits of physical activities facilitated through video gaming and demonstrate that "therapeutic" exercises coupled with action games can significantly improve balance [39] [40].

This work has led to the development of an engaging, game-based rehabilitation platform (GRP) [41]. The platform provides an integrated approach to decline in balance, mobility, vision, and cognition. In one form the GRP consists of a novel treadmill and interactive computer game subsystem. It includes a monitoring application which uses advanced data logging and analysis method to record the client's actions and choices while playing designed rehabilitation games. In this way, physical and cognitive performance during exercise can be monitored and quantified electronically. An inexpensive, commercial motion sense mouse (Gyrations, SMK-Link, USA) is used to control and interact with computer games. The motion-sense mouse is small with inertial sensors which are used to derive angular displacement signals. The motion sense mouse allows physical motion to be translated and interpreted as a standard USB mouse. Velcro secures the wireless motion mouse to a headband and with this simple method, responsive and high fidelity hands-free interaction with any computer game that is made possible using head rotation. Head pointing movements are among the most natural head rotations and can easily be performed with minimal instruction and by most people. Importantly this device allows modern and common commercial games to be utilized and enjoyed as part of an exercise or rehabilitation program. Many inexpensive computer games are available, which require: a) varied levels of movement speed and accuracy, b) tracking of multiple targets, c) stable gaze, and d) various executive cognitive functions. Thus, a broad range of visual-spatial and cognitive activities can easily be managed concurrently while performing demanding motor behaviours such as dynamic balance activities and treadmill walking while, for example, viewing a LED computer display and the novel application of the Gyration motion sense mouse.

There is an urgent need to develop and validate low-cost platforms of exercises and cognitive activities for age declines in mobility and cognition that could expand access of both rehabilitation and preventive measures to community centers. In this regard, computer games have received considerable interest from researchers and clinicians as a method to deliver together physical and cognitive activities. These emerging rehabilitation technologies and the use of digital media have the potential to improve clinical outcomes by making therapies and exercises more engaging and effective.

The present pilot trial is focused on describing the feasibility of conducting a definitive trial involving a novel game-based dual-task training program for balance, mobility, gaze and cognition. The intervention will be tested in individuals aged 70 - 85 who attend the Reh-Fit Centre (Winnipeg, Canada) for fitness training. The experimental group will receive a dual-task treadmill walking program (DT-TW) while the control group will receive a dual-task recumbent bicycle program (DT-RC). Both groups will perform the same cognitive activities delivered through interactive "cognitive" computer games.

2. Objectives and Hypotheses

The primary objectives are: a) to describe the feasibility and acceptability of the study design and process, procedures, resources and management [42]. It is expected that the study procedures, resources and management will be feasible. It is difficult to predict participant retention, exercise compliance rates as this trial will be piloting a novel exercise program; b) to explore the lived experiences of the study participants who completed their respective exercise programs. The broad research questions are "What were the experiences of the study participants with the dual-exercise programs and on what context were the experiences based upon?"

A secondary objective is to obtain preliminary data on the therapeutic effectiveness of the two dual-task training programs in older adults with a history of falls. The working hypothesis is that the group receiving the dual-task treadmill program will demonstrate significant improvement in balance, gait performance and cognitive measures under dual-task test conditions as compared to the recumbent bicycle group [43] [44]. In addition, it is hypothesized that executive cognitive function when assessed under single task conditions will improve significantly for both the treadmill and recumbent bicycle groups [45] [46].

The following are the reasons why we have chosen recumbent cycling as the active comparator group (control group). a) An existing study has examined dual-task recumbent cycling against recumbent cycling alone, and demonstrated significantly greater effects on cognitive performance for the dual-task program as compared to the cycling only exercise [31]; b) Resistance and speed settings during recumbent cycling, and thus level of physical activity, can be controlled; c) In order to present the participants of both groups with the types and levels of engaging cognitive tasks that will be used in this study, then clients need to view a computer monitor in order to interact with high fidelity cognitive or brain fitness games. Aerobic exercises or over ground walking type activities could not be used to control for physical activity; and d) We are also interested to see if recumbent cycling in addition to improving cardiac fitness and cognitive function does improve core balance. It should be noted that a number of older adults aged 75 - 90 years old and even younger are not able to walk on a treadmill but can use the recumbent bicycle.

3. Methods

A randomized controlled, single-blind pilot trial will be conducted. University of Manitoba Human Research Ethics Board (reference number: H2013:293) has approved the study protocol and informed consent will be obtained from all participant before their participation. Thirty participants not involved in a physical or cognitive training program will be recruited from the Reh-Fit Centre (Winnipeg, Canada). Inclusion criteria will be age between 70 - 85 years old, signed informed consent statement, the ability to walk 400 meters without walking aid, experienced at least one fall in the last year, adequate hearing and vision and speak English. Individuals who meet the initial eligibility criteria take part in a personal interview to screen for cognitive and health problems. People who score below 25 on the Mini Mental Score Examination (MMSE) [47] will be excluded from participating. Individuals who report more than one serious health complaint such as history of stroke, traumatic brain injury, uncontrolled hypertension, advanced orthopaedic or muscular-skeletal injuries and cardiac disease in the past six months will be excluded from participating. Individuals who report diagnosis of Alzheimer's disease, dementia will also exclude. All eligible participants will be informed individually about the content of the intervention and the study design will be explained. The participants will be asked to complete the Community Healthy Activities Model Program for Seniors (CHAMPS) that assessed the intensity and the frequency of their participation in various activities such as walking, gardening, housework, sports activities, and volunteering [48]. After that, participants will be randomly allocated into either the experimental group (DT-TW) or the control group (DT-RC) (**Figure 1**).

3.1. Recruitment

Recruitment and screening (including diagnostics) will be coordinated by staff (physicians, nurses, physiotherapists, member service and administration) at the Reh-Fit Centre, which is a health and fitness centre in Winnipeg, Canada for fitness training of the community, through informing clients of this research study and providing

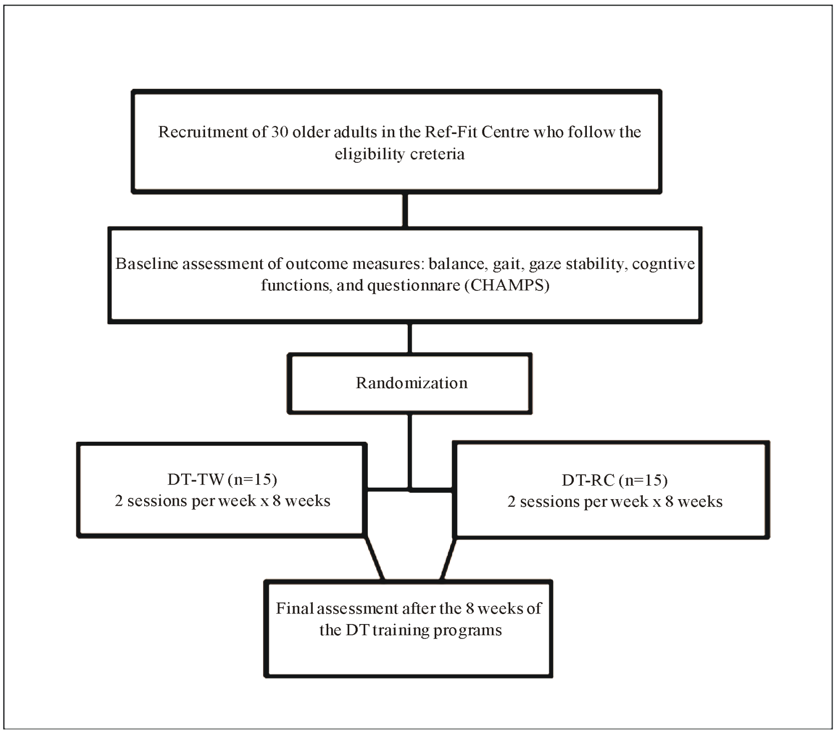

Figure 1. Presents summary of the study design (DT-TW: dual-task treadmill walking; DT-RC: dual-task recumbent bicycle).

them with a brief overview. Individuals will be recruited from the Reh-Fit Centre where participants come for leisure, exercise and physical activities. The Reh-Fit Centre has treadmills and recumbent bicycles that can be easily used by the members. Volunteers who are interested in participating in the study will contact the investigators via phone calls or electronic mails.

3.2. Randomization, Allocation Concealment and Blinding

The study is designed as a single Centre parallel group; assessor blinded randomized controlled pilot trial. Thirty participants will be randomly assigned to either control (DT-RC) or experimental (DT-TW) groups. Group assignment codes (number one for the DT-TW; number two for the DT-RC) will be placed in an opaque envelope and sealed. Each individual who agrees to enter the study will randomly select an envelope with the group assignment enclosed that offered by the blind assessor after completing the assessment. After that, the investigator opens the envelope with the participants and coordinating appointments for participant individual training sessions. Allocation of participants will be concealed.

3.3. Effect Size and Power Calculation

Based on the following criteria: a) group mean and standard deviation of one of the primary outcome measures, stride time variability measured during dual-task walking as reported in the literature [49], b) assuming a 20% change in stride time variability and c) using a sample size of 30, then effect size would be 0. 8 and the statistical power would be 89% (two tailed 95% CI).

3.4. Recruitment Rate, Rate of Loss and Program Adherence

Recruitment of a third of the participants deemed eligible for the training, a 15% attrition rate and 70% attendance rate for the dual-task program is acceptable [50]. For recruitment, data for the total sampling frame for inclusion into the study is taken to assess generalizability to all older adults within the community. The inclusion criteria rate will be based on the proportion of participants who enrolled into the training program and differentiate between those who refused, those who didn't respond and those who were willing but excluded (not meet the inclusion criteria). For attrition, we will measure the number of participants lost at follow up. For adherence to the primary program we will record compliance with all training sessions (**Table 1)**. There will be a total of 16 dual task-training sessions possible for each individual. Set at 640 minutes (2 sessions of 40 minutes/week). For the experimental group (DT-DW) spatial-temporal gait variables will be recorded during multiple, 2-minute training intervals for each session. For the control group (DT-RC) average workload and heart rate of multiple, 2-minute intervals will be recorded for each session.

3.5. Qualitative Study Methods

To understand study participants' lived experiences with their respective programs, individual interviews will be conducted and a qualitative analysis will be performed [51]. The experimental and control group participants who experienced the DT-TW and DT-RC programs will be formed individually. The 'essence' of lived experiences of the participants with their respective interventions will be captured by asking two broad questions: a) What have you experienced in terms of the intervention, and b) What context or situations influenced your experiences with the interventions. In addition specific probes aiming to obtain participants' perceptions related to a few topics, such as, a) content and delivery of the exercise programs; b) personal and environmental factors that influenced doing the exercise sessions, and c) recommendations or modifications for improving the exercise programs. Individual's facilitator and note taker will be blinded to the study groups. All interviews will be audio taped using a digital voice recorder, and will be transcribed verbatim. Themes, which are identified as an expression of the latent content of the text will be reported as textural and structural descriptions. As an example, themes could include: a) the program was appropriate, flexible and doable; b) were cognitive games engaging and fun, or difficult and frustrating; c) perceived exercise benefits; and d) perceived difficulties with the exercises and using the technologies.

3.6. Quantitative Study Methods

The demographic data including the age, gender, current medication, history of disease and fall will be collected

Table 1. Check list on the feasibility of trial procedures.

Study Participants
Participant recruitment procedures
Study inclusion criteria
Informed consent process
Assessment sessions (Pre & Post intervention)
Study outcome measures
Randomization procedures
Study Investigators
Suitable investigators in terms of qualifications, experience
Facilities do the investigators have at the Reh-Fit Centre
Weekly reminder
Responding to participants plans
Appointment for the sessions
Study Process
Retention rate
Adherence rate
Dropout rate
Fixing appointment for twice a week training sessions
Participants have the time to perform the dual-task training
Data Management
Managing the study at the Reh-Fit centre
Entering data into computer
Maintaining additional training program equipment for replacement
Treatment safety with the training program
Difficulties encountered with the program
Participants recommendation to the program
Power and Sample Size
How frequently does the outcome occur in the population
Expected range of the outcome, sample variance
The variability of other variables

at the initial assessment one week prior to start of the interventions. The following assessments will then be conducted at baseline and after completion of the 8-week training program:

1) Standing balance: Participants will be positioned on a treadmill 100 cm from an 80 cm computer monitor. Then, they will be asked to stand for 45 seconds on a fixed floor surface then on a compliant sponge surface while doing the following tasks; a) eyes open (EO), b) eyes closed (EC), c) head tracking task, and d) cognitive game tasks. As described by Desai *et al.* (2010) [11] force sensor array (FSA) pressure-sensing mat (Vista Medical Ltd., Manitoba, Canada) will be used to record vertical foot pressures for the standing tasks.

2) Gait Assessment: The following tasks will be performed while walking on a treadmill at 0.9 m/s for one minute each: a) Walk alone; b) Walk plus performing the head tracking task; and c) Walk while performing cognitive game tasks. A treadmill instrumented with a pressure mat (Vista Medical, CA) will be used to record vertical foot contact forces and used to compute spatial-temporal gait variables for all walking trials. At a walking

speed of 0.9 m/s, and duration of one minute, data for 30 consecutive steps will be obtained. Before starting testing, participants would be asked to walk for 5 minutes and acclimate to the treadmill.

3) Cognitive Assessment: A custom computer application with the following two assessment modules has been developed and will be used for this study: a) head tracking module and b) cognitive game module.

a) Head tracking module: This test involved tracking a bright visual target that moved horizontally (left and right) on a computer display for several cycles. Two cursors of different colors appear on the monitor. One is the computer controlled target cursor, which moves at a predetermined frequency of 0.5 Hz with amplitude of 70% of the monitor width. The second cursor is slaved to head rotation via a head-mounted motion mouse (Gyration, SMK-LINK Electronics, USA). The motion mouse is secured to a headband, and thus head rotation is used to control the motion of the second on-screen cursor. At a viewing distance of 100 cm, the task requires 800 of head rotation to move the cursor from side to side at a frequency of 0.5 Hz, this equates to an average head rotation velocity of 80˚/s and a peak velocity of 120˚/s. The goal of the tracking task is to maintain the overlap of the two cursors as the reference cursor moved from left to right or from bottom to top of the monitor. The tracking tasks will be performed for 45 seconds while the participant is standing on a fixed or sponge surface and during treadmill walking. The computer application generates a logged game file to record coordinates of the reference target cursor and the head rotation at 80 Hz, which is used for offline analysis of gaze performance as described below. b) Cognitive Game Module: A number of recent studies have used computer games to probe and evaluate visual-spatial cognitive functions, processing speed, and cognitive interference [52]-[54]. One such test is the Useful Field of View (UFOV), which is a validated, computer-based test that requires visual search mechanisms and the ability to select relevant information and ignore irrelevant information (cognitive inhibition) [55]-[57]. Similarly, the goal of the cognitive game of the present study to move a paddle (the game sprite) to interact with moving objects. During this task, head rotation (motion mouse) will be used to move the game paddle. Task complexity is configurable such that it can be simple involving a single target or more difficult involving additional target objects to catch with distracter objects to avoid. The two cognitive games tasks will be performed for 60 seconds while the participant is standing on fixed and sponge surfaces, and during treadmill walking at 0.9 m/s. The test game generates a logged game file that synchronously records (at an 80 Hz sampling rate) a) the time index and position coordinates of each game object as it appears; and b) the position coordinates of the game paddle, which is slaved to head rotation and represents the participant's actions and choices.

4) Walking endurance: will be measured using the 6-minute walk test [58].

The balance and treadmill walking tasks may be difficult when performing the concurrent head tracking and cognitive game tasks, and participants may lose their balance. The treadmill is equipped with safety side rails in easy reach, and participants would be fitted with a safety harness secured above to a support system. Also, during all tests, a physiotherapist will stand behind or beside the participants to provide assistance if required.

3.7. Intervention

Each participant will receive a 45 minute training program of combined exercise and cognitive activities twice a week for 8 weeks [29].Experimental group will receive DT-TW and control group will receive DT-RC. The interventions will be delivered by a physiotherapist who is trained in doing the dual-training exercise, and is proficient in the use of the computer and gaming systems.

1) Dual-task Treadmill Walking program Protocol: Participants will be positioned on the treadmill 100 cm from an 80 cm computer monitor. The protocol will begin with a balance exercise program of 10 minutes, which will also serve as a warm-up. Participants will stand on a compliant sponge pad or Swiss disc while performing different cognitive computer games. This will be followed by dual-task treadmill walking while performing cognitive computer games. This will involve interval training; 3-minute intervals of continuous walking plus gaming, with 2-minute rest periods. Total duration will be 30 minutes. The last five minutes will be used for cool-down and consist of treadmill walking alone at a speed similar to the client's natural over ground walking speed.

2) Dual-task recumbent bicycle protocol: The program will begin with a five minute warm up at a comfortable cycling speed at a target heart rate of 40% of maximum. The Max-Heart Rate will be calculated by using the formula (220-age) [59]. A cycling rate of 60 - 70 per minute will be used [60]. Resistance will be set at 3 to achieve the target heart rate, beginning with 40% and gradually increasing to 60%. This will be followed by dual-task recumbent bicycle while performing cognitive computer games. This will involve interval training; 3-minute intervals of continuous cycling plus gaming, with 2-minute rest periods. Total duration will be 30 min-

utes. The last five minutes will be used for cool-down and consist of cycling only, and at a target heart of 40% of max.

Both groups will perform the same cognitive activities delivered through interactive "cognitive" computer games. Eight computer games will be selected for each participant from a collection of over 60 purchased from Big Fish Games (www.bigfishgames.com). The computer games will involve goal-directed cognitive activities to include a) visual search and tracking of multiple targets; b) Precision movements of different speeds to interact with game targets; c) the presence of distracters; d) matching tasks; and e) working memory.

Training progression will be based on increasing both physical and cognitive challenges, individualized to the participant's level of performance. Balance cost will be increased by using different density of foam and then switching to a Swiss disc or other similar air bladder. Treadmill speed and cycling speed can be increased. Cognitive demands will be progressed by increasing game speed, number of game elements and distractors, complexity of game puzzles, and spatial processing.

4. Data Analysis

The supportive qualitative data will be analyzed by two investigators using a content analysis approach to identify characteristics of preferences for importance of the participants experienced in term of the intervention and the context or situation influenced their experiences with either DT-TW or DT-RC training program. Content analysis is a tool to determine the presence of certain words with the use of exemplar quotes to support the use of certain words [61]. Each interview transcript was reviewed and reported as textural and structural description. The responses from participants will be simultaneously coded into themes that encompassed similar characteristics of content. A phrase or comment could be coded under more than one theme.

For the quantitative data, Custom built MATLAB scripts (The Math Works, Natick, MA, version 2010a) will be used for extracting all the dependent variables from the data recorded.

Balance performance: The root mean squared (RMS) COP excursions in the anterior-posterior (AP) and medial-lateral (ML) dimensions will be computed for each task. Increase in COP excursion will be interpreted as a decrease in stability [62] (**Figure 2**).

Spatial-temporal gait variables: Average and coefficient of variation (30 consecutive steps) of stance and swing durations, single support times, and step width and length are determined from ML-COP and AP-COP trajectories (**Figure 3**).

Gaze Performance: The coordinate data of the computer target and the user's head rotation (motion mouse) will be used to compute gaze performance. A non-linear least squares algorithm will be used to obtain a sine-wave function of the reference target cursor waveform. Head rotation trajectories will be fit to the sine-wave function, and the coefficient of determination (COD) will be computed based on total and average residual difference between the trajectories of the target and head cursor motions. Values approaching one equate to perfect overlap of the two cursors and excellent gaze performance (**Figure 4**).

Cognitive Performance Measures: The overlay trajectories (head rotation) of the individual head pointing movements for each game event obtained from one game session. Each game event was 2 seconds in duration from target appearance to target disappearance. Different features of the segmented game movements provided a basis for the quantification of cognitive functions. For a detailed description of the game movement segmentation and analysis of the individual contextual game events see Lockery *et al.*, 2011 [63]. As illustrated in **Figure 5(b)** and **Figure 5(c)**, the following variables, averaged over left and right game movements of medium amplitude, will be determined: a) average response time (*i.e.* the time from the appearance of the target to start of the paddle movement); and b) Average movement execution time (*i.e.* the time from beginning of the movement to the final location). The game success rate was also determined as the percentage of target objects that were caught. Other researcher's [64] [65] are used pointing movements and similar methodologies to examine executive cognitive functions (**Figure 5**).

1) Dual Task Performance: A proportional dual-task costs (DTC) for balance measures, spatial-temporal gait variables, gaze performance and cognitive performance will be calculated according to the formulae: dual-task measure minus single-task measure divided by the single-task measure and expressed as a percentage of 100. The DTC will express the effects of the additional costs imposed in individual-task performance by a concurrent dual-task.

2) Cognitive function will be assessed using four standardized neuropsychological tests, which are: Trial

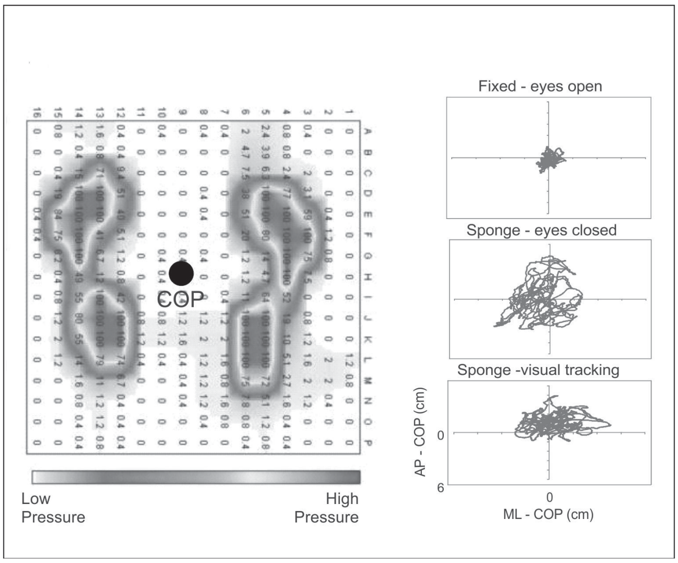

Figure 2. Presents a snapshot of the pressure mat in standing and example XY-plots of ML-AP COP excursions for different test conditions on fixed and sponge surfaces.

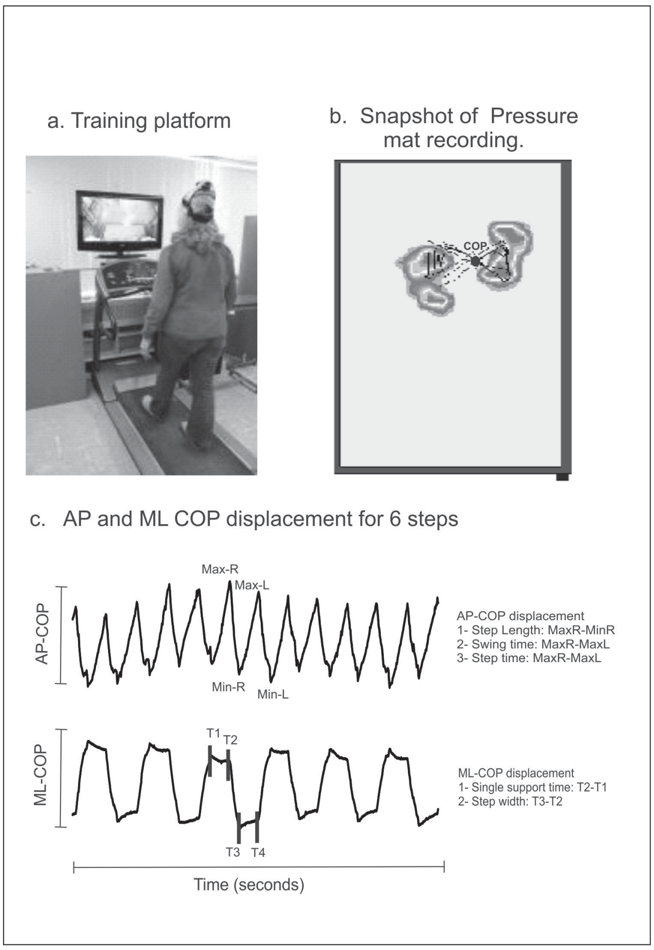

Figure 3. Presents the set-up and snapshot of the treadmill pressure mat, example XY-plots of ML-AP COP excursions.

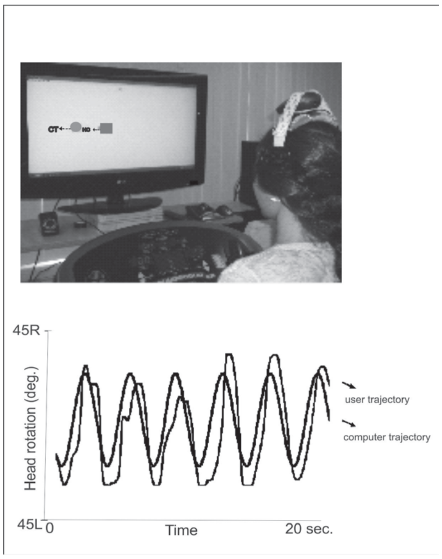

Figure 4. Presents the head tracking task and presents synchronous plots of the target cursor motion and user head rotation for a typical tracking task.

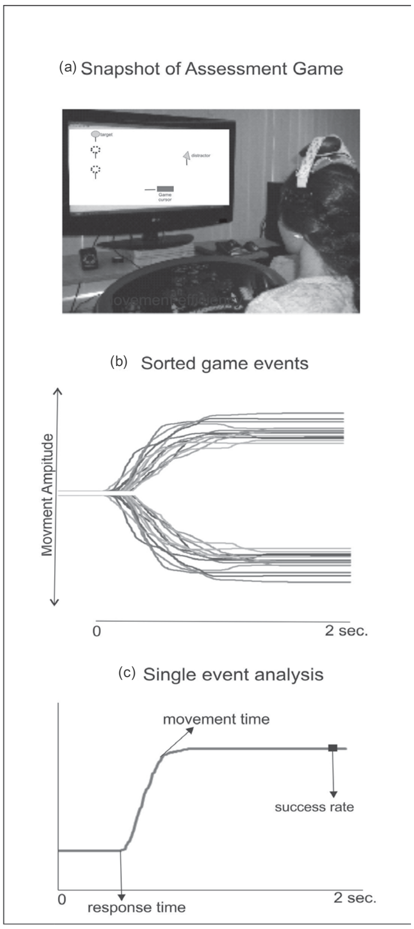

Figure 5. Presents the overlay trajectories (head rotation) of the individual head pointing movements for each game event obtained from one game session.

Making Test (TMT A and B) [66] visual search test [67] [68], and verbal Fluency Test (Animal/ FAS) [49] [69].

3) Cardiac fitness: Heart rate and cycle workload (power in Watts) will be recorded for each 2-minute training interval of dual task recumbent bicycle (Techno-gym USA Corp.). A Spree sports heart rate monitor will be used for this purpose. Heart rate per unit workload will be calculated for each interval and training session over the 8-week training program.

All statistical procedures will be conducted with the SPSS (version 22.0) software program (SPSS Inc. Chicago, IL, USA). Demographic characteristics and baseline data will be summarized by descriptive statistics using means, standard deviations and 95% confidence intervals for continuous variables, median and inter-quartile ranges for non-normal continuous or ordinal data and percentages for categorical data, and will be evaluated for normalcy and homogeneity. Only individuals who completed the entire trial will be counted towards the final results. A comparison of group data at baseline will be undertaken using a Mann-Whitney U-test and the chi-squared test for the dichotomous variable. Analysis of covariance (ANCOVA) will be used to test the changes in dual task cost (DTC) of balance measures, spatial-temporal gait variables, gaze stability and cognition. The dependent variable is the post-intervention measurement of the outcome, the covariate is the pre-intervention measurement, and group membership as the between-subjects effect. Descriptive statistics, including measures of skewness and kurtosis, will be used to assess departures from the assumptions of a normal distribution of responses. If the distribution contains extreme observations, a robust ANCOVA statistic will be adopted [70]. Results will be considered significant at $P < 0.05$. The magnitude of effects statistics will be calculated for the differences between the groups at post training and expressed as Cohen d statistic. Small, moderate, or large effects will be identified based on standard criteria of 0.2, 0.5, and 0.8 or greater [71].

5. Discussion

This research project will determine the feasibility of a novel dual-task gaming intervention and assessment subsystem as a platform for assessment and treatment of balance, mobility, gaze, cognition and dual-tasking functions. The qualitative findings of participant's experiences will help to identify a) difficulties in using the technologies; b) the personal and, environmental factors that influenced doing the exercises; c) the motivational value of the computer games; and d) to provide recommendations and modifications for improving the exercise programs.

Physical activity combined with cognitive enrichment has the potential to impact the management and prevention of balance impairments, mobility limitations, decline in cognitive function and increased fall risk. The results of this pilot study will allow us to assess the potential for successful implementation of the novel intervention and technology and to identify any unpredicted harm or side effects. With an effect size of 0.8 and power of 89% a preliminary estimation of within and between group effects for the primary outcome measure would be acceptable. Taken together it is expected that these results will contribute to the study design, and will provide justification to proceed with an adequately powered randomized controlled trial [72]-[74]. Results of the study will also provide a better understanding of the functional consequences of decline in physical and mental skills with age. Improved methods of screening and fall risk assessment in the community which can be linked with quality, engaging interventions is important because continued difficulties and fall injuries will have a sizable impact on this large population.

Evidence on the efficacy of preventing fall in geriatrics is not explained yet and large randomized control trials are needed. Fall prevention interventions should include dual task training (*i.e.* physical activity and mental skills) aspects relating to fall, task-specific and generalized training, with the intervention focused on the older adults need. Results of the study will provide us with a new knowledge of rehabilitation intervention care that combines technologies with dual task training to decline fall risk and enhance locomotion in elderly population.

Competing Interests

None of the authors have any financial, personal, or potential conflict of interest with the material presented in this article

Author Contributions

Rehab Alhasani, Akshata Nayak, and Tony Szturm participated in designing the study, writing and reviewing of the manuscript. Sue Boreskie, Geri Brousseau, and Mayur Nankar participated in reviewing the manuscript. All authors read and approved the final manuscript.

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