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A NEW ADAPTIVE HOME-BASED EXERCISE TECHNOLOGY AMONG OLDER ADULTS LIVING IN NURSING HOME: A PILOT STUDY ON FEASIBILITY, ACCEPTABILITY AND PHYSICAL PERFORMANCE

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Abstract

Objectives—To explore the feasibility and acceptability of a new home-based exercise technology among older adults and to evaluate its efficacy on physical performance measures.

Design—Longitudinal clinical trial.

Setting—Oak Hammock at the University of Florida, a nursing home located in Gainesville, Florida.

Participants—Twelve pre-disabled older adults (≥75 years) living in a nursing home with a Short Physical Performance Battery (SPPB) score between 6 and 9 and no diagnosis of dementia.

Intervention—Thirty minutes of light intensity exercise (aerobic, strength and balance) two times per week for four weeks using a home-based physical activity technology called Jintronix.

Measurements—Feasibility and acceptability were assessed through a 9-item self-administered questionnaire and by exploring the percentage of quality of movements and time performing exercise which was calculated automatically by Jintronix technology. Physical performance measures were assessed through the SPPB score at baseline, after 4 weeks of intervention and after 3 months from the completion of the intervention.

Results—Twelve older adults (80.5±4.2 years old) performed light intensity exercise with Jintronix for a total of 51.9±7.9 minutes per week. Participants reached 87% score of quality of movements in strength and balance exercises, a global appreciation score of 91.7% and a global

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difficulty score of 36%. Compared to baseline, there was a significant improvement in SPPB score at the end of the intervention and at 3 months following the completion of the exercise program (0.67±0.98 and 1.08±0.99 respectively, p-value <0.05).

Conclusion—Jintronix technology is feasible and acceptable among pre-disabled older adults without dementia living in nursing home and is beneficial in improving their physical performance.

Keywords

Exercise technology; nursing home; physical activity; physical performance

Introduction

Sedentary lifestyle is highly prevalent and has been associated with many cardio-metabolic disorders (1, 2) as well as overall mortality (3). In particular, in older adults, sedentary time is related to reduced muscle mass and increased risk of sarcopenia (4) which has been associated with an increased risk of falls and disability, loss of independence and even increased mortality (5–7). Moreover, prolonged periods of sitting, particularly TV watching, are independently associated with reduced muscle strength and functional performance among older adults (8–10). Despite the wide-ranging health benefits of physical activity, the majority of older US adults are inactive with only 16% of individuals aged between 65 to 74 years report practicing the recommended 30 minutes or more of moderate physical activity at least 5 days per week (11). In addition, it is important to note that individuals living in nursing homes are typically less active than community-dwelling older adults (12).

A recent review has described multiple barriers that lead older adults to engage in sedentary behaviors in the nursing home: health issues (e.g. stroke, paralysis, arthritis and limited mobility), psychological barriers (e.g. fear of falling or lack of motivation), medications related to chronic diseases and organizational and environmental barriers (e.g. no dedicated space for exercise equipment or no kinesiologist available in the nursing home) (13). These findings support the necessity of implementing health programs in nursing homes in order to encourage older adults to decrease sedentary behavior and to increase regular physical activity. Innovative and engaging exercise programs represent a promising approach to help older nursing home residents overcome their barriers to physical activity and thereby increase their physical activity levels.

Another review article showed that only twelve intervention studies had beneficial effects on physical performance in nursing home residents (14). These interventions (mostly strength or walking exercises) were often performed using supervised group sessions, with the help of external staff, rehabilitation professionals (e.g. physiotherapists or occupational therapists), researchers, or a combination of these, which are very costly interventions. The use of an innovative home-based exercise technology individualized for each nursing home resident, easy to use independently and without a need of a face to face intervention, could help both the residents to overcome their barriers and the health-professional staff to overcome the organizational and environmental issues to physical activity participation in a cost-effective manner.

Toward this objective, this study explored the feasibility and acceptability of a new home-based exercise technology called Jintronix and evaluated its efficacy to improve physical function in twelve pre-disabled older adults living in a nursing home.

Methods

Design and Setting

This was a longitudinal single arm clinical trial. The exercise intervention was performed in a private room of the main building of Oak Hammock at the University of Florida, a nursing home located in Gainesville, Florida. Oak Hammock is an innovative life fulfilling community for the 21st century, where the focus is on lifelong learning, fitness and health. The setting is a picturesque, resort-style environment enhanced by intellectual stimulation and energized by a unique affiliation with the University of Florida. Because of this affiliation, it is traditionally known as a Continuing Care Retirement Community (CCRC), but it is also known as a University Based Retirement Community (UBRC). As a Continuing Care Retirement Community, it offers a maintenance free lifestyle in independent homes and apartments, but also access to assisted living, skilled nursing, and memory care facilities.

Participants and Funding—Older adults aged ≥ 75 years were recruited among the residents of Oak Hammock through flyers and informational presentations in situ. Inclusion criteria included: age 75 years and older, pre-disabled status evidenced by 6 ≤ score ≤ 9 on the Short Physical Performance Battery (SPPB) test (15) and willingness to participate in all study procedures. Exclusion criteria included: failure to provide informed consent; severe cardiac disease, including NYHA Class III or IV congestive heart failure, clinically significant aortic stenosis, history of cardiac arrest, use of a cardiac defibrillator, or uncontrolled angina pectoris; significant cognitive impairment, defined as a known diagnosis of dementia or a short portable mental status questionnaire score > 2 errors (16); unable to communicate because of severe hearing loss or speech disorder; severe visual impairment, which would preclude completion of the assessments and/or exercise program; other significant co-morbid diseases that would prevent participation in exercise and planning to move out of the area during the study timeframe. The University of Florida Gainesville Health Science Center Institutional Review Board reviewed and approved the study protocol. A total of twelve participants agreed to participate and gave written informed consent.

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Exercise Intervention

Jintronix technology—Jintronix (www.jintonix.com) is a home-based physical activity technology that has been used to perform the exercise intervention in this study. Jintronix has been approved by the Food and Drug Administration (FDA number: K143034) and has been validated with stroke populations aged 40 to 70 (17). Jintronix is an easy-to-use virtual physical activity platform designed for physical and occupational therapy. It combines common exercise movements, virtual games and motion sensing cameras to offer a fun,

interactive and effective tool for physical activity. Jintronix is made of two powerful components: Jintronix Wave and Jintronix Portal. The Jintronix Wave is the participant application platform: it is a group of engaging clinically validated physical exercises, set in a virtual environment and designed by experts in physical and occupational therapy. The Jintronix Wave is made of hardware, a TV screen and a Microsoft Kinect motion tracking camera that was installed in a private room of Oak Hammock's main building. The Jintronix Wave recorded the participant's movements in real time and registered many clinical metrics such as speed, precision, and range of motion. In particular, in order to determine the participants' quality of movements (part of the feasibility outcome of this study) Jintronix used an optical motion capture system called Kinect system (Microsoft). The Kinect infers body position by using an infrared emitter that projects a pattern of infrared light into a room. As the light hits a surface, the pattern becomes distorted, and the distortion is read by a depth camera. The depth camera analyzes the patterns to build a 3D map of the room and all the people within it. Using the 3D depth map, the Kinect software is able to infer human joint positions. This process takes places with a frequency of 30 times per second.

All the information collected by Jintronix Wave were transmitted to a secure service (Jintronix Portal) where all the data were accessible through a Web application portal. Data were monitored by the principal investigator in his office.

Training and exercise program—The exercise intervention program was made of one visit of exercise training and eight sessions of light intensity physical activity using Jintronix. During the one visit of personal training, participants learned how to use the Jintronix technology, in particular how to switch on the software, how to enter into the program with their personal ID and how to perform all the exercises independently. Each participant was trained personally by an expert in Jintronix technology in a private room located in the main building of the nursing home. At the end of the training visit, participants received the schedule of their eight sessions of exercise intervention with individualized date and time.

The exercise intervention was performed independently by each participant for 4 consecutive weeks, for 2 times per week for 30 minutes per session, for a total of 8 sessions or 240 minutes of physical activity. The Jintronix technology with the TV screen were placed in a private room of the main building at Oak Hammock and the participants were asked to engage in a 4 weeks of physical activity program following a detailed schedule. Each participant was asked to go to the nursing home's main building where a private room was set up with a TV screen and the Jintronix technology. The nursing home's main building was connected to the participants' homes by elevators, so they didn't have to walk more than 100 meters to reach the exercise room. Each participant performed the exercises intervention alone, with the supervision of a clinical study coordinator for security reasons. The clinical study coordinator was asked not to interfere with the exercise intervention or with the participant's schedule.

The exercise program was designed to meet the exercise and physical activity guidelines for older adults established by the American College of Sports Medicine (ACSM) and American Heart Association (18, 19). Participants performed light intensity exercises for 30 minutes

per session. Each session was divided in three sub sessions with 1 minute of resting after each sub sessions. The three sub sessions and the exercises performed are described below:

1. AEROBIC exercises: walking in place, sideway walking, arm circles, two side steps with arm forward, toe pointed with arms up and marching in place with arms.
2. RESISTANCE and STRENGH exercises: lateral weight shift and squatting, controlled movements with right and left arm, bilateral coordination and foot eye coordination with leg flexion.
3. BALANCE exercises: walking forward and backward, walking left and right, trunk flexion and stepping.

Outcome Measures

Feasibility & acceptability (20–21)—Feasibility was assessed by:

- A quality of movements' total average score > 80% that was automatically calculated by the Jintronix software using its own algorithms (20) and
- An appreciation total average score > 80% or > 2.4 points that was calculated by a 9 item feasibility questionnaire performed at the end of the intervention. In particular, the appreciation score for the single participant was calculated through the answer to the question: "How much did you like the Jintronix technology?" If the participant answered "a lot" the score was 3 points, "moderately" = 2 points, "a little" = 1 point and "I didn't like it" = 0 points.

Acceptability was assessed by:

- An average total time in performing the exercises for 12 participants > 80% of expected exercise time or > 192 minutes (3.2 hours) out of 240 minutes (4 hours) (21). The total time in performing the physical activity program was calculated automatically by the Jintronix Software for each participant at the end of the program and
- A difficulty total average score < 40% or < 1.2 points that was calculated by a 9 item feasibility and acceptability questionnaire performed at the end of the intervention. In particular, the difficulty score for each single participant was calculated through the answer to the question: "How difficult did you find the Jintronix technology?" if the participant answered "very difficult" the score was 3 points, "quite difficult" = 2 points, "not difficult at all" = 1 point and "it was easy" =0 points.

Physical performance—Physical performance was assessed using the Short Physical Performance Battery (SPPB) test. The SPPB is a common measure of physical performance in older adults and is described elsewhere (15). Briefly, the test is comprised of timed measures of standing balance in three positions (side by side position, semi tandem position, tandem position), walking speed over 4 meters, and time to stand up and sit down 5 times in a chair, as quickly as possible. Each of the 3 performance measures were assigned a score

ranging from 0 to 4 according to normative data published elsewhere (15), with 4 indicating the highest level of performance and 0 the inability to complete the test. A summary score was created by adding each performance score and ranges from 0–12. Values for the speed (or time) to complete each task and score were reported. The test was performed at baseline, at the end of the intervention and after 3 months from the completion of the intervention.

Other measures

Demographics characteristics and medical illnesses information were collected at baseline. Physical activity levels were assessed through the Rapid Assessment of Physical Activity (RAPA) (22) questionnaire which was administered at baseline and after 3 months from the completion of the intervention. The RAPA questionnaire has been validated elsewhere among older adults (22). The final version of the RAPA was a nine-item questionnaire with the response options of yes or no to questions covering the range of levels of physical activity from sedentary to regular vigorous physical activity as well as strength training and flexibility. The instructions for completing the questionnaire provide a brief description of three levels of physical activity (light, moderate, and vigorous) with graphic and text depictions of the types of activities that fall into each category. The total score of the first seven items is from 1 to 7 points, with the respondent's score categorized into one of five levels of physical activity: 1 = sedentary, 2 = underactive, 3 = regular underactive (light activities), 4 = regular underactive, and 5 = regular active. Responses to the strength training and flexibility items are scored separately, with strength training = 1, flexibility = 2, or both = 3.

Data Analysis

Participants' baseline characteristics are reported as counts, means or percentages. Comparisons were made between physical performance measures at baseline, at the end of the intervention and after 3 months from the completion of the intervention using a paired t-test Wilcoxon matched-pairs signed-ranks test for a non-parametric distribution of repeated measures in a small sample size. The effect size for this test was calculated by dividing the z value (statistic output of the statistical software) by the square root of N. In this situation N = the number of observations over the two time points. Stata statistical software version 11.0 (StatCorp, College Station, Tex) was used for all analyses and results were considered statistically significant at $p < 0.05$.

Results

Table 1 describes the baseline characteristics of the twelve participants who completed the exercise program with Jintronix. Overall, participants were 80.5 ± 4.2 years old and they were female (83.3%) and white (100%). The majority of the participants reported good or excellent health (91.7%), were able to walk 1 mile (66.7%) and had a normal body mass index (22.5 ± 2.9 kg/m2). The most prevalent disease was hypertension. Table 2 describes the feasibility and acceptability measures. Participants completed 86.3% of the total sessions of exercise with an average of 208 minutes per week and a maximum of 240 minutes. The quality of movements' total average score for strength and balance exercises was 87% over 100% with a total average appreciation score of 2.75 over 3 points and a total average

difficulty score of 1.08 over 0 points. Table 3 shows, compared to baseline, a significant improvement in SPPB score after 4 weeks of intervention and after 3 months from the completion of the intervention with a large effect size (0.67 ± 0.98 and 1.08 ± 0.99 change respectively, p-value < 0.05, r = −0.40 and −0.56 respectively). Among SPPB sub-scores: there was a significant improvement in 4 meter walking speed (0.06 ± 0.09 m/s, p-value < 0.05, r = 0.50) and a significant reduction in time in completing the chair to stand test (0.91 ± 1.27 s, p-value < 0.05, r = 0.41) after 4 weeks of the intervention. Finally, after 3 months from the completion of the intervention, there was a significant improvement in the RAPA score (0.5 ± 0.8, p-value = 0.05, r = −0.40) meaning that participants increased their physical activity levels after the completion of the exercise program with Jintronix.

Discussion

This study demonstrated that a home-based exercise technology, individualized for each participant, easy to use independently and without a need of a face to face intervention, is feasible and acceptable among pre-disabled older adults living in nursing home. Moreover, this research showed that the exercise technology tested improves physical performance of the nursing home residents: in particular, there was a significant increase in walking speed and a significant reduction in time to complete the chair to stand test after four weeks of light intensity physical activity intervention. These changes were all clinically meaningful (23). Interestingly, after three months from the completion of the exercise program we found an improvement also in questionnaire-based physical activity levels of the nursing home old participants.

Physical inactivity is more prevalent among older people living in nursing home, and this group is growing faster than other age groups in developed countries (14). While insufficient activity negatively affects their health and quality of life due to its association with chronic diseases (1–2), disability and mortality (3), it also imposes economic burden on the society.

This research helped the scientific and medical community to explore important topics on nursing home older adults which has received little attention in the past few years.

A recent review article concluded that one of the most important organizational barrier to physical activity among older adults living in nursing home is staff’s lack of time to incorporate physical activity into the residents’ daily routine and lack of support from nurses, families, and doctors (13). Moreover, the majority of residents suggested that physical activity programs were not adequately tailored, boring, and not challenging (13). This study demonstrated that a home-based exercise technology may help the nursing home staff to overcome this organizational barrier by showing that older adults are able to perform the exercise program alone, without any assistance. On the other hand, this research demonstrated also that Jintronix, which utilizes engaging and easy to use tailored virtual games, may help residents to improve their physical activity levels, and easy to use.

Another review article demonstrated that participation in exercise programs enhances health related fitness, reduces risk taking behavior, and creates saving through lower utilization of various healthcare services (24). By testing an easy to use home-based exercise technology,

this research has provided the initial step to helping the scientific and medical community evaluate an innovative instrument that has the potential to reduce the economic burden connected to late-life disability by improving physical activity levels and functional performance of a fragile nursing home population.

Finally, this is the first study demonstrating that a home-based exercise technology improves physical performance measures of older adults living in nursing home. Many previous intervention studies were based on face-to-face or group based physical activity program with the help of a professional instructor and were directed specifically to rehabilitation (25) or in preventing falls (26). In addition, the use of new exercise technologies has been limited only on home-based nurse care systems (27), tele health tools to support family caregivers (28), web based physical activity programs for neurological or cardiac (29) tele rehabilitation or on the use of robots for neurodegenerative disorders (30). To our knowledge, this is the first study to use a home-based exercise technology to specifically improve physical performance measures and physical activity levels in pre-disabled older adults with great success in these outcomes.

Limitations

This study has some limitations. First, the sample size was small because it was a pilot study whose main outcome was to test the feasibility and acceptability of Jintronix among pre-disabled older adults living in nursing home. Second, there was not a control group to compare the benefits of Jintronix or a face-to-face traditional intervention with an instructor or personal trainer or to compare Jintronix with other exergame technology. Finally, although participants had an SPPB score between 6 and 9 with a pre-disabled status, they were relatively healthy and they lived in the nursing home without any special assistance.

Conclusions

This study demonstrated that older adults without dementia living in nursing home are able to use a home-based exercise technology with beneficial effects on their physical performance measures and physical activity levels.

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Table 1

Descriptive characteristics of the overall population

Characteristics	Overall Sample (12 participants)
Age	80.5 ± 4.2
Gender (Female)	10 (83.3)
Race (White)	12 (100)
Education (HS or higher degree)	10 (83.3)
Health (Good or Excellent)	11 (91.7)
Able to walk 1 mile	8 (66.7)
Prevalent Disease	
Hypertension	3 (25)
MI	1 (8.3)
CHF	0 (0)
Stroke	0 (0)
Cancer	2 (16.7)
Diabetes	0 (0)
Arthritis	0 (0)
COPD or Asthma	1 (8.3)
Hypotirodism	1 (8.3)
Number of falls in the past year	0.36 ± 0.67
BMI (Kg/m2)	22.5 ± 2.9
Short mini mental status score	0.08 ± 0.29
SPPB score	8.2 ± 1.19
RAPA score	3.92 ± 1.31
RAPA strength score	0.83 ± 0.83

Values represent, N (%) for categorical variables or mean ± standard deviation for continuous variables unless otherwise stated;

Abbreviations: HS = high school; MI = myocardial infarction; CHF = chronic heart failure; COPD = chronic obstructive lung disease; BMI = body mass index; SPPB = short physical performance battery; RAPA = rapid assessment of physical activity.

Table 2

Feasibility and acceptability scores

	Score after Jintronix intervention	Expected minimum score
Session completed	6.9±1.1 (86.3%)	6.4 (80%)
Minutes performed	207.5±32.5 (86.5%)	192 (80%)
Appreciation score	2.75±0.45 (91.7%)	2.4 (80%)
Difficulty score	1.08±0.29 (36%)	1.2 (40%) *
Quality of movements	87.0%	80%

Values represent, N (%) for categorical variables or mean ± standard deviation for continuous variables unless otherwise stated.

* Expected maximum score for the difficulty score.

Table 3

Physical performance measures at baseline (a) after 4 weeks of intervention (b) and after three months from the completion of the intervention (c)

Physical performance measures	Baseline (a)	After 4 weeks of intervention (b)	p-value (a vs b)	Effect size (a vs b)	After 3 months from the completion of the intervention (c)	p-value (b vs c)	Effect size (b vs c)	p-value (a vs c)	Effect size (a vs c)
SPPB total	8.2 ± 1.2	8.8 ± 1.3	0.05	−0.40	9.3 ± 1.1	0.03	−0.46	0.006	−0.56
Balance score	2.9 ± 0.9	3.3 ± 0.7	0.20	−0.26	3.4 ± 0.7	0.32	−0.20	0.09	−0.35
Walking speed (m/s)	0.73 ± 0.14	0.79 ± 0.13	0.02	0.50	0.79 ± 0.12	0.94	−0.02	0.008	0.54
Chair to stand (s)	14.8 ± 2.6	13.9 ± 2.3	0.04	0.41	13.7 ± 2.2	0.24	0.24	0.02	0.50
RAPA	3.9 ± 1.3	N/A	N/A	N/A	4.4 ± 1.5	N/A	N/A	0.05	−0.40
RAPA strength	0.8 ± 0.8	N/A	N/A	N/A	0.9 ± 1.0	N/A	N/A	0.32	−0.20

Values represent mean ± standard deviation for continuous variables unless otherwise stated.

Abbreviations: SPPB = short physical performance battery; RAPA = rapid assessment of physical activity.