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# Video-games used in a group setting is feasible and effective to improve indicators of physical activity in individuals with chronic stroke: a randomized controlled trial

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**Abstract**

**Objectives:** To investigate the feasibility of using video-games in a group setting and to compare the effectiveness of video-games as a group intervention to a traditional group intervention for improving physical activity in individuals with chronic stroke.

**Design:** A single-blind randomized controlled trial with evaluations pre and post a 3-month intervention, and at 3-month follow-up. Compliance (session attendance), satisfaction and adverse effects were feasibility measures. Grip strength and gait speed were measures of physical activity. Hip accelerometers quantified steps/day and the Action Research Arm Test assessed the functional ability of the upper extremity.

**Results:** Forty-seven community-dwelling individuals with chronic stroke (29-78 years) were randomly allocated to receive video-game (*N*=24) or traditional therapy (*N*=23) in a group setting. There was high treatment compliance for both interventions (video-games-78%, traditional therapy-66%), but satisfaction was rated higher for the video-game (93%) than the traditional therapy (71%) ($\chi^2$=4.98, *P*=0.026). Adverse effects were not reported in either group. Significant improvements were demonstrated in both groups for gait speed (F=3.9, *P*=0.02), grip strength of the weaker (F=6.67, *P*=0.002) and stronger hands (F=7.5, *P*=0.001). Daily steps and functional ability of the weaker hand did not increase in either group.

**Conclusions:** Using video-games in a small group setting is feasible, safe and satisfying. Video-games improve indicators of physical activity of individuals with chronic stroke.

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## Introduction

Physical activity promotes health and plays an important role in preventing recurrent stroke and functional deterioration.[1] However, many individuals with stroke do not maintain an adequate activity level.[1,2] Approximately one fifth have a significant decline in mobility years after their stroke.[3] Therefore, there is a unique challenge to help maintain the mobility status in these individuals.

Different approaches have been utilized for increasing physical activity in chronic stroke. Participation in community programs is a cost-effective way of providing a structure for physical activity and maintaining mobility while promoting socialization.[4] Community exercise programs may provide additional motivation, increase compliance and adherence for exercising, which is especially important for individuals who are often socially isolated or restricted in participation following their stroke.[5] The effectiveness of community gait training programs, cardiorespiratory fitness programs and lower-limb strengthening programs to improve leg muscle strength, balance, gait speed, walking distance and walking competency has been established.[4] Motor and functional abilities of the upper extremity were also reported to improve after participating in specific community upper extremity exercise programs.[6]

Commercially available video-game consoles have also been utilized as a way to promote physical activity for adults[7] and children. As recreational devices, they include entertainment (and music), imbedded competition, and have been reported to enhance the enjoyment[8] and motivation[9] of players while engaging in physical activity. Video-games provide challenging, relevant and intensive training that is motivating, repetitive and task-specific; factors essential for neuroplasticity to occur.[10,11] Compared to traditional therapy, video-games have been found to increase the intensity of training, elicit more upper extremity purposeful movements,[12-14] increase energy expenditure, and promote motor recovery after stroke.[15,16] To date, video-games have not been used in a group setting.

In view of the potential benefits, we designed a program that combined community based treatment and video-game activities for individuals with chronic stroke. This study aimed 1) to investigate the feasibility of using video-games for a community group setting and 2) to compare the effectiveness of a 3-month video-game group intervention to a traditional group intervention for improving factors related to physical activity in individuals with chronic stroke.

## Methods

### *Study design*

This study is a single-blind randomized controlled trial (clinical trial number NCT01304017) with assessments administered pre and post the 3-month intervention and at a 3-month follow-up by assessors blind to group allocation.

### *Population*

Individuals were eligible if they lived in the community, 18 to 80 years of age and sustained a single stroke at least 6 months prior to the study. Additional inclusion criteria included the ability to walk at least 10-meters (with or without an assistive device or physical assistance), weakness of the upper extremity (determined by the upper extremity subtest of the Fugl-Meyer Motor Assessment),[17] and without a significant cognitive deficit (score above 21 points on The Mini Mental State Examination).[18] Individuals with other neurological conditions or epilepsy were excluded from the study. Individuals were first stratified into two subgroups according to the severity of the upper extremity motor impairment; below or above 30/60 points on the Fugl-Meyer Motor Assessment[17] and then randomly assigned the a video-game or traditional group intervention. The study was approved by the Hospital Helsinki Committee and University Ethics committee and all individuals provided written informed consent.

## Tools

In addition to the screening tools the following measures were used to characterize the population. The presence of depressive symptoms was assessed by The Geriatric Depression Scale.[19] The Functional Reach Test,[20] a brief and valid test of balance,[21] was used to assess standing balance by the difference in centimeters between a standing position to leaning forward while maintaining a fixed base of support. Independence in basic activities of daily living (BADL) was assessed by the interview version of the Functional Independence Measure (FIM),[22] which has been found to be reliable and valid; total scores ranges from 18 (dependant) to 126 points (independent). Independence in instrumental activities of daily living (IADL) such as shopping, cooking and housework was assessed using the IADL questionnaire;[23] total scores range from 0 (not independent) to 23 points (totally independent in IADL). Demographic information, date and type of stroke, were collected from the participants and their family physicians. The assessments were administered in the rehabilitation center where the intervention took place. Participants received reimbursement for the travel costs for the assessment sessions only.

*Outcome measures.* Primary outcomes: Feasibility was defined as acceptance of the intervention modality (video-games or traditional therapy in a group setting) and was assessed by *the compliance* (session attendance - percentage attended out of 25 sessions), *satisfaction level* and *adverse effects*. A questionnaire regarding their satisfaction and perceived benefit was completed following the intervention; items were rated from 1 (not at all) to 5 (very-much). Adverse effects (namely pain, dizziness, and falls) were monitored during the intervention sessions.

Efficacy was assessed using the following primary outcome measures: *Gait speed* which is a common outcome measure for interventions providing physical fitness[4] was measured by the 10-meter walk test,[24] a valid and reliable test commonly used with stroke population.[25] Participants were requested to walk at a comfortable speed while using their walking aid on a 14-meter path and gait speed for the middle 10-meters was measured and reported as meter/sec. This test was administered twice and the mean gait speed was calculated.

*Grip strength* which is predictive of important outcomes such as disability[26] in older adults, was measured 3 times by using a Jamar Dynamometer[27] (handle positioned in setting 2), alternating between hands. The mean strength per hand was calculated and reported in kg.

The secondary outcome measures were the *number of steps walked per day* and *the functional ability of the weaker upper extremity*. Number of steps per day is an indication of the amount of physical activity. Following each assessment session, individuals wore a hip accelerometer (Acticial Minimitter Co.) which has a step count function for three consecutive days, with the mean total steps per day calculated from total steps divided by three.[28] The Action Research Arm Test,[29] is a valid and reliable measure of upper extremity function. Scores range from 0 (non-functional) to 57 (fully functional) points.

*The intervention.* The intervention included 2 one-hour sessions a week for 3-months while gradually increasing the physical demands. The sessions were provided by 3-4 occupational therapists to groups of 6-8 participants. Three groups of traditional therapy and four groups of video-games were run in total. The occupational therapists selected the consoles, games (video-game intervention) and activities (traditional intervention) according to the participant's ability to move his/her upper extremity, maintain balance and walk. The occupational therapists also provided physical and/or verbal guidance if needed and supervised the participants to prevent falls. Participants were encouraged to use their weaker upper extremity to play and interact with the virtual objects (video-game intervention) perform movements and activities (traditional intervention), but if this was not possible, they were guided to hold their weaker hand with their stronger hand to integrate it into function. Socializing was promoted in both groups; playing video-games and performing activities and exercises traditional therapy were done in pairs. The importance of attending all the sessions was stressed and attendance was marked each session.

*The video-game group intervention.* Three out of the five following video-game consoles were used alternately each session and were set up in three work stations; Microsoft Xbox Kinect, Sony PlayStation 2 Eyetoy, Sony PlayStation 3 MOVE, Nintendo Wii Fit and the SeeMe VR system (http://www.virtual-reality-rehabilitation.com/), which was developed specifically for rehabilitation. Each session started with a 5-minute group warm up of walking while playing a Wii Fit walking/jogging game. Subsequently participants were divided up into the work stations; played games in pairs on one console then rotated to play another console with another partner. The occupational therapists combined their clinical knowledge with the characterization of the consoles to select the consoles and games. See online Supplementary Table for the list of games played on each console. All games were played in pairs while standing. Some consoles/games allowed playmates to play simultaneously, if not, participants took turns. While waiting for their turn, participants were encouraged to either play “outside” of the game, or to respond (sit-to-stand, clap hands) every time their playmate scored. Participants too tired to do so, rested until their turn.

*Traditional group intervention.* The exercises and functional activities were adopted from existing community group programs such as the Fitness and Mobility Exercise Program,[30] the Graded Repetitive Arm Supplementary Program[31] and the task-oriented intervention[32] that have been reported to be effective for individuals with subacute and chronic stroke. Whereas previous traditional interventions provided either upper[6,32] or lower extremity[33] exercises, we combined them to match the whole-body video-game stimulation. The sessions started with a group warm up of upper and lower extremity movements, stretching, marching and arm swings, followed by walking around the rehabilitation building for 5 minutes. Participants were then divided into pairs or triads to perform functional activities such as picking up and transferring objects from one side of the room to the other.

### Statistical analysis

Descriptive statistics were used to characterize the sample and outcome measures on the three assessments. The percentage of participants who reported high compliance (attendance at least 75% of the sessions)[34] and high satisfaction from the intervention (4 (satisfied) or 5 (very satisfied)) was calculated and compared between the two groups using Chi square. A repeated measures ((3)X2) analysis of variance ANOVA was used to compare within and between groups scores with repeated measures for time (pre-intervention, post-intervention and follow-up) between the video-games and traditional therapy and for interaction time*group effect. The sample size was calculated to detect a minimally clinically important difference of 0.14 m/s in gait speed[35] with 80% of power and a significance level of 0.05 and to account for a 15% drop out rate, at least 24 participants per group should be recruited. Intention-to-treat analysis was conducted with the last observation carried forward method.

## Results

Forty-one participants completed the intervention and 37 participants attended the follow-up assessment (see Figure 1 for participant flow according to the Consolidated Standards of Reporting Trials (CONSORT) guidelines). Twenty participants completed the video-games training; the age range was 29-69 years, and they were nine months to 6.2 years post stroke. Twenty-one participants completed the traditional therapy; the age range was 42-78 years,

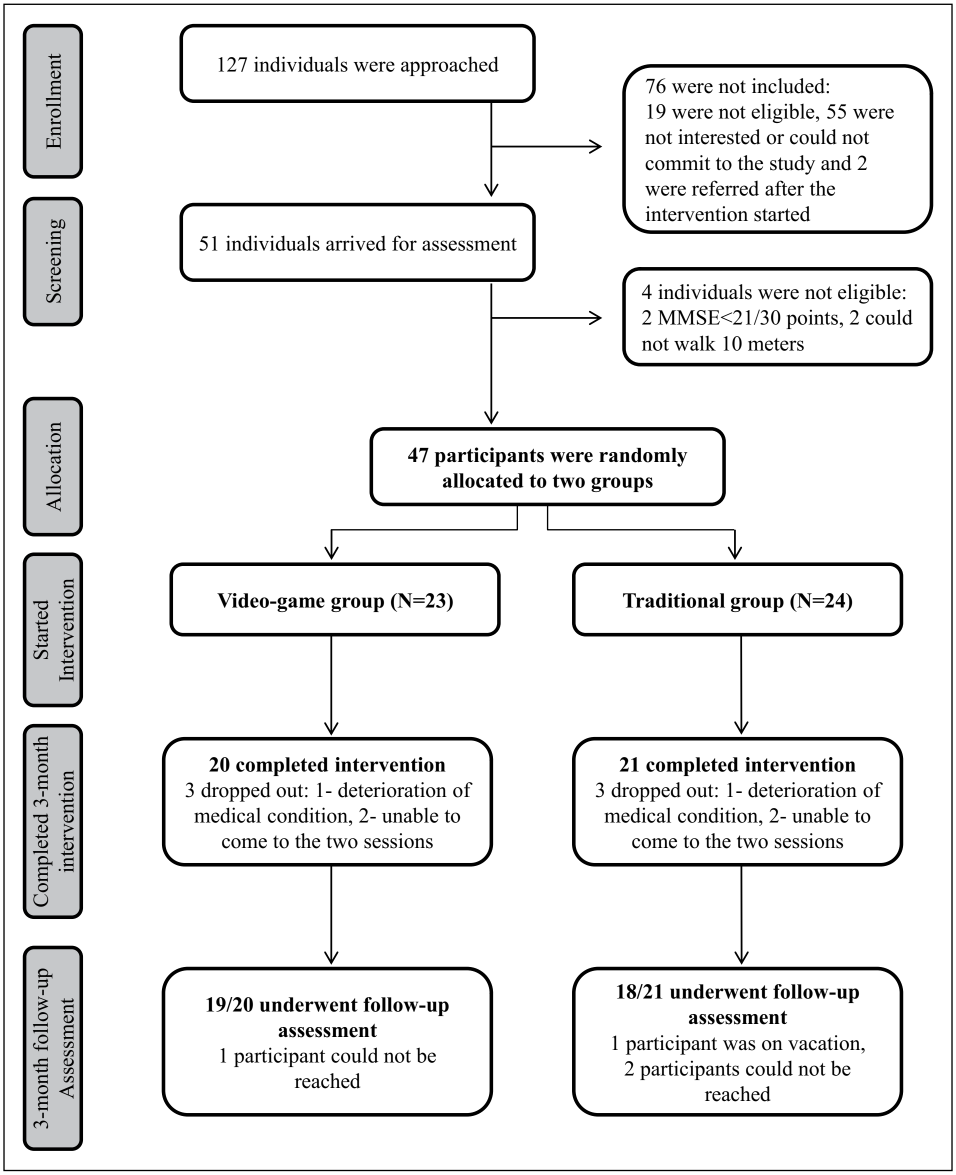


**Figure 1.** CONSORT of the study.

and they were six months to 7.6 years post stroke. All participants were cognitively intact, mostly independent in BADL with varying independence in IADL. No significant differences were found in the participant's demographic or stroke data pre-intervention (see Table 1). Both groups were heterogeneous in terms of time since stroke onset, upper extremity motor impairment and standing balance (Table 1).

## *Feasibility*

High *compliance* was found in 78% of the participants in the video-game group and 66% for the traditional

**Table 1.** Demographic, stroke and functional characteristics of the participants in both groups.

| | Video-game group intervention N=24 | Traditional group intervention N=23 | Independent samples t-test |
|---|---|---|---|
| | Mean (SD)<br>Min-Max | Mean (SD)<br>Min-Max | t (p) |
| Age (years) | 56.7 (9.3)<br>29–69 | 62.0 (9.3)<br>42–78 | −1.9 (0.06) |
| Time since stroke (years) | 3.0 (1.8)<br>0.8–6.2 | 2.6 (1.8)<br>0.6–7.6 | 0.8 (0.4) |
| Education (years) | 13.5 (2.2)<br>10–20 | 14.3 (3.6)<br>11–26 | 0.4 (0.7) |
| Cognition - Mini Mental State Examination (0-30) | 28.5 (1.2)<br>26–30 | 28.1 (1.9)<br>24–30 | 0.9 (0.3) |
| Independence in BADL – Functional Independence Measure (18-126) | 107.2 (13.2)<br>76–124 | 102.9 (13.5)<br>75–122 | 1.1 (0.2) |
| IADL Questionnaire (0-23) | 15.0 (4.6)<br>7–23 | 11.8 (6.1)<br>3–23 | 2.0 (0.051) |
| Motor impairment of the weaker upper extremity –Fugl-Meyer Motor Assessment (0-60) | 32.2 (20.5)<br>5–60 | 26.5 (19.6)<br>0–58 | 0.9 (0.3) |
| Standing balance - Functional Reach (cm) | 20.1 (6.9)<br>7.5–30.5 | 17.6 (6.2)<br>5.0–25.5 | 1.3 (0.19) |
| | *N* (%) | *N* (%) | $\chi^2$ (*P*) |
| Gender | | | |
| Men | 11 (47.8) | 17 (70.8) | 2.6 (0.1) |
| Women | 12 (52.2) | 7 (29.2) | |
| Dominance | | | |
| Right | 21 (91.3) | 24 (100) | 2.2 (0.1) |
| Left | 2 (8.7) | 0 (0) | |
| Stroke side | | | |
| Right | 14 (60.8) | 16 (66.7) | 0.2 (0.7) |
| Left | 9 (39.2) | 8 (33.3) | |
| Type of stroke | | | |
| Hemorrhagic | 3 (12.5) | 4 (17.3) | 0.2 (0.6) |
| Ischemic | 21 (87.5) | 19 (82.6) | |
| Depressive symptoms* | | | |
| Yes | 5 (21.7) | 3 (12.5) | 0.7 (0.4) |
| No | 18 (78.3) | 21 (87.5) | |
| Residence | | | |
| Alone | 1 (4.3) | 3 (12.5) | 1 (0.3) |
| With family | 22 (95.7) | 21 (87.5) | |
| Employment | | | |
| Working | 6 (26) | 5 (20.8) | 0.8 (0.7) |
| Not working | 12 (52) | 11 (45.8) | |
| Retired | 5 (22) | 8 (33.4) | |

*Depressive symptoms present as calculated by a score of 10 or higher on the Geriatric Depression Scale.

group, which was not statistically significant ($\chi^2$=0.18, p=0.66). Ninety three percent of the participants in the video-game group expressed high *satisfaction* as compared to 71% in the traditional group which was statistically significant ($\chi^2$=4.98, p=0.026). *Falls or other adverse effects* were not reported in either group during the period of the study.

### Efficacy

Primary outcome measures: Significant within-subject effects were found for gait speed (F=3.9, *P*=0.02), demonstrating an improvement for both groups between pre to post evaluations (F=4.5, *P*=0.04), however, it was not maintained at follow-up. Significant improvement for both groups was also demonstrated in grip strength of the weaker hand (F=6.67, *P*=0.002) between pre to post (F=8.1, *P*=0.007), and pre to follow-up measurements (F=6.2, *P*=0.017). Grip strength of the stronger hand of both groups improved as well (F=7.5, *P*=0.001), between pre to post (F=24.8, *P*=0.000) and pre to follow-up measurements (F=9.1, *P*=0.004). These findings are presented in Table 2.

Secondary outcome measures; There was no significant change in daily steps walked as assessed by accelerometers, or the functional ability of the upper extremity as assessed by the Action Research Arm Test in either group.

## Discussion

The use of a video-game group intervention was found to be feasible and safe to promote indicators of physical activity of community-dwelling individuals with chronic stroke.

The setup of three workstations, the use of different video-game consoles and the game competition, especially against other playmates within the group setting, created an environment that offers opportunities to make choices and competition, thus enhancing their intrinsic motivation in general and specifically for engaging in physical activity.[36] This resulted in high compliance and low drop-out rates in comparison to previous studies[31,34] and greater satisfaction compared to the traditional group. Video-games delivered in a group settings seemed to keep the participants motivated and challenged, offering variability in exercise, providing for intensity and frequency of training sessions, encouraging meaningful task-related movements, and providing feedback, thus implementing the main principles of rehabilitation.[37] Potentially, similar video-game group interventions could be run in community centers to provide this population with a continuing program to maintain physical activity, functional ability, to promote socializing and to prevent decline. Moreover, for individuals living in rural areas who are less likely to receive post-acute stroke rehabilitation therapy,[38] video-game group intervention may offer a reasonable alternative. Additionally, trained family members or caregivers could potentially help run these groups (help set-up the workstations, teach the games and supervise the participants while they play). Therefore video-game group intervention meets most of the criteria for successful implementation of technology in clinical practice.[37]

Both groups showed improvement in grip strength of the weaker and stronger hands from pre to post-intervention and post-intervention to follow-up. Grip strength in older adults has been shown to be related to leisure time physical activity[39] frailty,[40] disability[4] and even mortality. In our study, improvement was achieved in both groups, and continued to improve following the intervention, possibly due to increased hand use at home. However, the functional ability of the upper extremity did not change significantly. Our findings are similar to those reported by other authors[41,42] that showed minimal to no improvements in the functional ability of the upper extremity after video-game training in chronic stage post-stroke.

Improved gait speed, which was achieved for both groups, is also an indicator of increased physical activity with important functional implications.[43] This improvement is possibly due to the fact that the video-games were played while standing and five-minute group walking “through” Wii Fit beach, park and caves scenarios was the warm for each session. Since the transfer to steps walked per day in the community was not achieved, we recommend adding more walking time to the

**Table 2.** The primary and secondary outcome measures of the two groups pre-intervention, post-intervention and at follow-up.

| | Video-games group intervention | | | | | Traditional group intervention | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Pre | Post | Follow-up | %ΔPre-post | %ΔPre-FU | Pre | Post | Follow-up | %ΔPre-post | %ΔPre-FU |
| | Mean (S.D) | Mean (S.D) | Mean (S.D) | | | Mean (S.D) | Mean (S.D) | Mean (S.D) | | |
| | Min-Max | Min-Max | Min-Max | | | Min-Max | Min-Max | Min-Max | | |
| Grip strength-weaker hand | 12.1 (11.7) | 13.7 (11.7) | 13.4 (12.1) | 13.6 | 11.9 | 9.6 (9.6) | 11.9 (11.0) | 11.4 (10.1) | 23.1 | 18.2 |
| | 0–45 | 0–45 | 0–44 | | | 0–37 | 0–45 | 0–41 | | |
| Grip strength-stronger hand | 28.0 (12.0) | 31.4 (10.8) | 33.9 (13.1) | 12.2 | 22.2 | 30.4 (9.4) | 35.6 (11.0) | 35.2 (10.0) | 17.0 | 15.7 |
| | 9–60 | 14–60 | 14–61 | | | 12–47 | 17–52 | 15–52 | | |
| ARAT (0-57) | 28.5 (23.2) | 28.4 (23.1) | 28.9 (24.3) | −0.3 | 1.6 | 21.9 (22.4) | 23.7 (24.0) | 25.4 (25.2) | 8.3 | 16.3 |
| | 0-57 | 0–57 | 0–57 | | | 0–57 | 0–57 | 0–57 | | |
| Gait speed (m/sec) | 0.9 (0.4) | 1.0 (0.4) | 1.0 (0.4) | 6.3 | 3.2 | 0.7 (0.3) | 0.8 (0.4) | 0.7 (0.3) | 12.4 | 2.5 |
| | 0.1–2 | 0.1–2 | 0.1–2 | | | 0.1–1.4 | 0.2–1.6 | 0.2–1.4 | | |
| Steps walked/day | 3368.0 (3385.1) | 3786.8 (4178.2) | 3154.0 (4781.5) | 8.8 | −4.8 | 2655.5 (2645.9) | 2540.2 (2593.5) | 3502.0 (3086.5) | −4.3 | 31.9 |
| | 147–14010 | 200–14627 | 206–18462 | | | 190–9702 | 66–8068 | 156–9558 | | |

Grip strength – kg, ARAT – Action Research Arm Test to assess functional ability of weaker upper extremity.

protocol of future programs correspondingly to other community gait training programs.[6,33]

Limitations of this study include the heterogeneous motor ability in both groups, and the fact that the participants in the traditional group were older with greater balance and upper extremity impairments compared to the video-game group. Possibly with a more homogeneous sample and balanced groups, differences between groups could have been detected. However, the feasibility of using a video-game group intervention for individuals with chronic stroke with varying motor abilities was established. Also possibly higher intensity of the interventions might have led to greater benefits. In the future, information regarding intensity, such as perceived exertion, should be added.

**Clinical messages**

- Using video-games in a small group setting is feasible, safe and satisfying for individuals with varying motor abilities in the chronic stage post stroke.
- Similar to traditional group therapy, video-games played in a group setting improve indicators of physical activity of individuals with chronic stroke.

## Conflict of interest

The authors declare no conflict of interest.


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