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**ORIGINAL ARTICLE**

# Mind-Fun Study: Feasibility of Square-stepping Exercise in Assisted Living Homes

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## Abstract

***Background:*** We proposed Square-stepping exercise (SSE) as a novel intervention in continuum care (CC) and long-term care (LTC) homes and conducted a pilot cluster randomized trial [2 SSE sites (2x/wk for 12-weeks) and 2 control sites]. ***Objective:*** Our primary goal was to determine the feasibility of SSE via recruitment, attendance, and program fidelity. ***Methods:*** At baseline (V0) and post-intervention (V1) we assessed: cognition (Cambridge Brain Sciences), and mood and behaviour symptoms [participants with dementia (questionnaire)]. Participants (n = 71) were 81.7 (SD 11.4) yr old, and 75% female. ***Results:*** Kinesiologists found SSE socially beneficial; however, there is limited feasibility as the overall attendance rate was 40.5%. The SSE improved mood and behaviour symptom scores in participants with dementia (total, frequency, and severity), all $F > 1$, $p < 0.05$. No differences in cognition were seen. ***Conclusions:*** Further research is needed to determine the effectiveness of SSE on cognition; however, the feasibility is limited in diverse groups. **Health & Fitness Journal of Canada 2017;10(4):3-22.**

*Keywords*: Older Adults; Cognition; Retirement Living; Long-term Care; Dementia; Cognitive Training; Intervention; Randomized

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## Introduction

The number of adults older than 85 yr of age is growing (Canadian Institute for Health Information (CIHI), 2011), as is the number of older adults living in collective dwellings (i.e., seniors residences or health care facilities) (Milan et al., 2012). Adults living in long term care (LTC), continuum care (CC), and retirement living (RL) homes have higher prevalence of cognitive impairment and dementia than their community dwelling counterparts (Graham et al., 1997; Guo et al., 2012)[1], which is related to social isolation and loneliness (Bellou et al., 2017; Shankar et al., 2013), as well as physical inactivity and depression (Norton, Matthews, Barnes, Yaffe, & Brayne, 2014). Furthermore, reduced cognition is associated with lower physical functioning and mobility (Giuliani et al., 2008; Hirvensalo et al., 2000).

Aerobic, resistance, and multiple modality exercise interventions, as well as, cognitive and dual-task training programs, have shown benefits for

[1] Continuum care refers to a range of assisted living situations that range from retirement (i.e., independent) living to LTC (i.e., nursing care).

improving cognition (Baker et al., 2010; Colcombe & Kramer, 2003; Dorfman et al., 2014; Erickson et al., 2011; Kelly et al., 2014; Lampit et al., 2014; Liu-Ambrose et al., 2012; Nagamatsu et al., 2013; Suzuki et al., 2013; Voss et al., 2014) and reducing depression (DiLorenzo et al., 1999; Singh et al., 2001) in older adults with and without cognitive impairments. However, these studies are primarily conducted in healthy community-dwelling older adults.

In this study, we proposed a mind-motor training program, known as Square-stepping exercise (SSE), which was developed as a falls prevention program for community-dwelling older adults in Japan (Shigematsu & Okura, 2006). It is a visuospatial working memory task with a cued stepping response (i.e., cognitive training with a physical component), that challenges balance skills and fosters positive social interactions through feedback from peers. An instructor demonstrates a stepping pattern across a gridded mat and participants are required to memorize and repeat the patterns. Square-stepping exercise has been shown to improve falls risk, balance, lower extremity functional fitness, and strength as well as global cognitive functioning, memory, and executive functioning in community-dwelling older adults (Gill et al., 2016; Shigematsu & Okura, 2006; Shigematsu et al., 2014; Shigematsu et al., 2008; Teixeira et al., 2013). Lastly, SSE is a, group-based program that is simple to implement, requires minimal equipment and staff requirements and thus, an appropriate intervention to assess in LTC and CC homes.

Our primary aim was to determine if the SSE program was feasible in LTC and CC homes, through assessment of recruitment, attendance rates, and program fidelity. Our secondary aims were to assess whether our outcome measures were feasible in populations with diverse cognitive and mobility impairments through the number of participants who could complete the assessments. Additionally, we aimed to determine if a 12-week SSE program improved: global cognitive functioning (GCF), or domain-specific function (memory, concentration, planning, or reasoning) in residents in CC or LTC homes compared to a control group. Lastly, we aimed to determine if a 12-week SSE program improved mood and behaviour symptom scores in residents living with dementia compared to a control group (with dementia). We hypothesized that a 12-week SSE intervention would be feasible and benefit of the cognitive health of residents in LTC and/or RL settings.

## Methods

### Study Design

We collaborated with the Schlegel Villages (a group of 16 long-term care and continuum care homes in Ontario Canada) and Waterloo-Schlegel Research Institute for Aging (RIA). Of the 16 homes, four sites volunteered to be involved in the study. The village staff kinesiologists (i.e., Registered Kinesiologists and/or Exercise Therapists) develop monthly exercise programs for the residents at each of the sites, both one-on-one and group exercises, specific to the level of care (e.g. retirement living or long-term care). The kinesiologists implemented the SSE program as a part of their regular exercise programming with the residents. The kinesiologists were trained to deliver SSE during a one-hour SSE training session conducted by study personnel and given a written protocol of the program.

We conducted a pilot cluster

randomized controlled trial (RCT), whereby four sites (two LTC and two CC homes) were stratified by level of care and randomized to the SSE program or wait-list control. Randomization sequence was computer generated with concealed one to one allocation. Using a wait-list control group allowed assessment of SSE feasibility after changes from the intervention sites were implemented, as well as provided a comparator group for outcome measurements. To keep anonymity of the sites, they will be referred to as: site 1 (SSE group; LTC site), site 2 (SSE group; CC site), site 3 (control group; LTC site), and site 4 (control group; CC site). Therefore, the SSE and control group each contained one LTC and one CC home.

All residents from the four sites were invited to participate in the program, regardless of cognitive or mobility impairments (i.e. no exclusion criteria). The purpose was to maintain a pragmatic approach to the study design.

To recruit the residents, information sessions were held, and an article was included in the monthly newsletter at each of the four sites. Additionally, the kinesiologists at each site approached residents or their family members for their interest.

Participants (decision makers) provided written informed consent prior to collecting any data. The study was approved by the University of Western Ontario Health Sciences Research Ethics Board (No. 107891), and the RIA research ethics. It was conducted with accordance to the Helsinki Declaration. This study was registered in clinicaltrials.gov (No. 10012765).

## Participant Characteristics

To describe our population, the following participant characteristics were obtained at baseline: sex, age, marital status, race, years of education, blood pressure, presence of depression, height, weight, use of a walking aid, and transfer status. We also collected a list of medications and diagnoses. The diagnoses were added to create a Charlson Co-morbidity index score per the weighted criteria (Charlson et al., 1987). When available, these data were obtained from residents' charts at each of the homes, which was extracted by village or RIA staff to maintain confidentiality.

In participants without previously diagnosed cognitive impairments, we conducted a Montreal Cognitive Assessment (MoCA). Evidence suggests that adults who self-report cognitive complaints are at higher risk of cognitive decline and expressing worry about declining cognition further advances this progression of cognitive decline (Jessen et al., 2010; Jessen et al., 2014; Jessen et al., 2014). Therefore, we asked the following questions regarding their opinions on their cognition: 1) do you feel your memory and/or thinking skills have gotten worse recently (yes or no)? For the participants who responded 'yes', two additional were asked: 1) what would you say has gotten worse (i.e., memory, thinking skills, or both)? and 2) are you concerned/worried about your worsening memory and/or thinking skills (yes or no)?

## Intervention

Residents participated in a progressive 12-week SSE intervention. An instructor demonstrated stepping patterns across the gridded SSE mat (250cm x 100cm, partitioned into four columns with 10 rows). The residents were required to try and remember the stepping pattern and then repeat it on their own. SSE is a group-based program where the

participants are encouraged to help one another and engage as a team with peer-to-peer coaching, with minimal assistance from the instructors. There are more than 200 validated patterns that range from beginner to advanced with two to sixteen steps; to increase difficulty, steps include forward, backward, horizontal, and diagonal directions.

To be inclusive of residents with severe mobility impairments who were interested in the program, we developed a 'hand SSE mat'. It is a miniature version of the large SSE mat (25cm x 10cm), which was fastened to a legal length clipboard. The residents participating in the hand SSE were provided with the same protocol; however, they were required to remember the pattern and then repeat the pattern on the miniature mat with their fingers instead of walking across the mat. This helped to increase engagement in the program and inclusivity of all residents to provide cognitive and social stimulus to those with physical impairments. This modification provides an opportunity to gain a greater understanding of SSE's feasibility within our study sites.

The program ran for 12 weeks (2 days/week; 60-minute sessions) at each of the sites. Each session consisted of five to ten minutes of warm-up exercises and stretching, 45 minutes of SSE, and five to ten minutes of cool down and stretching. Attendance was taken at each session and program progression was monitored via attendance logs. Because SSE was implemented as a part of the kinesiologists scheduled programming, residents who were not enrolled in the study were still able to participate in the SSE program.

**Wait-list Control**

The two sites that were randomized as wait-list control completed the study assessments (i.e., completed pre- and post-intervention assessments) without any intervention. After the post-intervention assessments, the control sites were invited to implement the SSE program so all residents had an opportunity to participate.

**Feasibility of the intervention**

The primary outcome was to determine the feasibility of SSE in LTC and CC homes. To assess feasibility, we examined: 1) recruitment through the number of participants enrolled; 2) attendance rates through the number of residents who attended each SSE session; and 3) program fidelity to determine if the program was delivered as intended through anecdotal feedback from kinesiologists. We also monitored the number of residents who participated in SSE but were not enrolled in the study to determine if there was further interest in participating in SSE without enrollment in the research study. Feasibility was assessed at all four sites, regardless of group allocation. The kinesiologists delivered the SSE intervention as they felt appropriate for their residents, which was assessed through feedback (i.e., email, phone call or in person) from the kinesiologists.

**Outcomes and Assessments**

The assessments were completed pre-intervention (V0; June 2016) and post-intervention (V1; September-October 2016), during one-and-a-half-hour time blocks with the research team at each of the sites.

**Mood and Behaviour Questionnaire**

The kinesiologists completed the Neuropsychiatric Inventory Questionnaire (NPIQ) for participants living with dementia only, in both SSE and

control groups. This questionnaire evaluates symptoms of a patient over a one week period and it is recommended and intended to be administered by a professional caregiver, specifically, someone who is familiar with behaviours of the patient (Cummings et al., 1994). The NPIQ is a 12-item questionnaire that assesses mood and behaviour symptoms and it has shown to be valid and reliable (Cummings et al., 1994). The questionnaire is scored based on: 1) presence of symptoms (0, 1), which are totalled for a score out of 12; 2) frequency of symptoms (1-3); and 3) severity of symptoms (1-4) for each applicable questionnaire item.

**Cognition.** The cognitive outcomes were: global cognitive functioning (GCF) and the four cognitive domains (memory, concentration, planning and reasoning). These were assessed using the computer-based Cambridge Brain Sciences (CBS) cognitive battery (Hampshire et al., 2012). These tasks are based on well-established neuropsychology paradigms and are well supported by literature (Baddeley, 1968; Cattell, 1949; Collins et al., 1998; Corsi, 1972; Folstein et al., 1975; Gould et al., 2005; Inoue & Matsuzawa, 2007; Shallice, 1982; Silverman et al., 2000; Stroop, 1935; Treisman & Gelade, 1980; Weshcler, 1981). A subset of eight games were used, instead of the full battery of 12, to minimize participant fatigue (See Supplementary Table 1). The CBS games are an objective measurement of cognition and minimize assessor bias; additionally, they do not require a clinician to administer them like the traditional paper-based neuropsychiatric assessments. Furthermore, the CBS games are dynamic and change with the participant's responses, thus there is not a learning effect associated with the CBS games.

The CBS games were completed based on each individual's abilities; therefore participants with diagnosed dementia did not complete the games. Those with some cognitive impairments completed some of the games, while the remainder completed the battery of eight games.

When possible, the CBS games were completed on touch screen computers at each of the four sites, otherwise laptops with an external mouse were used. The participants completed a familiarization session of the games prior to completing the assessment at V0 and V1. The residents were assisted by study personnel during the familiarization session to ensure they understood how to use the computer and games, after which the participants completed the games on their own.

## Feasibility of the outcome measurements

Feasibility of the outcome assessments was determined to assess whether the outcomes chosen were appropriate for our study population. This was done through assessing the number of participants who were successfully able to complete the measurements pre- and post-intervention. The purpose was to determine the acceptability of the outcome measurements for a larger, pragmatic trial.

## Power and sample size

The primary aim of this study was feasibility rather than obtaining statistical significance and therefore, we did not calculate a sample size (Thabane et al., 2010). We recruited all willing participants interested in the program at each of the four villages.

**Table 1: Study site characteristics by cluster group.**

| Characteristic | Site 1 | Site 2 | Site 3 | Site 4 |
|---|---|---|---|---|
| Level of Care | Long term care | Continuum care | Long term care | Continuum care |
| Total No. of beds | 192 | 369 | 256 | 311 |
| Residents enrolled | 15 | 15 | 17 | 24 |
| Group Allocation | SSE group | SSE group | Wait-list control | Wait-list control |

## Statistical Analyses

SPSS version 24 was used to analyze data and we used Analysis of Covariance (ANCOVA), controlling for baseline.

For all continuous variables of interest, distributions were examined to assess normality and presence of outliers. For categorical variables, frequency tables were examined to ensure there are no out-of-range values.

From the CBS, there are two planning tasks, two memory tasks, two reasoning tasks, and two concentration tasks. We created composite standardized z-scores for each domain. Then to create a GCF composite score, the four domain-specific z-scores were averaged. We did not generate a GCF if any domain-specific score was missing. Since this was a pilot cluster RCT and our primary outcome was feasibility, we did not account for clustering in our model because it was not statistically possible.

We examined outcomes descriptively for each group and site, which included: GCF, domain specific function (four), and mood and behaviour symptom scores. The observed values at V0 and V1 were summarized descriptively for each site and group. We used an ANCOVA to examine differences between groups at V1, controlling for V0.

A number of sensitivity analyses were considered, including adjusting for age, sex and years of education as covariates. Exploratory analyses were conducted, whereby we analyzed the data looking at level of care as a factor as well as within group and within sex. Statistical significance was set at $p<0.05$; however, since this was a feasibility study we also interpreted effect size, reported as partial eta squared ($\eta_p^2$, where 0.1 is small, 0.25 is medium and 0.4 is large).

## Results

Recruitment for the study began on 16 May 2016 and was completed on 30 June 2016. Outcome data collection (V1) was completed on 4 October 2016 and the wait-list control group completed the intervention in February 2017. We recruited 71 participants: site 1, n = 15; site 2, n = 15; site 3, n = 17; and site 4, n = 24 (see Table 1). Participants were [mean (SD; range)]: 81.7 (11.4; 38-100) years old with Charlson Co-morbidity Index of 2.9 (SD 1.6) (See Table 2 and Supplementary Table 2) and an additional 19 residents tried the SSE program even though they were not enrolled in the study.

## Feasibility of the intervention

The average attendance across all enrolled participants at all sites was 40.5 % (n = 71). The average attendance rate excluding participants who attended zero sessions was 52.3% (n = 55). The average attendance rate of participants with >50% attendance was 77.7% (n = 30) (See Table 3).

**Table 2: Participant characteristics by study site.**

| Characteristic | Site 1 (n = 15) | Site 2 (n = 15) | Site 3 (n = 17) | Site 4 (n = 24) |
|---|---|---|---|---|
| Age, years, mean (SD) | 76.5 (14.8) | 84.5 (10.4) | 78.9 (13.9) | 85.2 (4.7) |
| Female sex, No. (%) | 10 (66.7) | 13 (86.7) | 11 (64.7) | 19 (79.2) |
| Married, No. (%) | 4 (46.7) | 7 (46.7) | 4 (23.5) | 9 (37.5) |
| Caucasian, No. (%) | 15(100) | 14 (93.3) | 16 (94.1) | 22 (91.7) |
| Height, cm, mean (SD) | 159.0 (11.6) | 159.5 (9.8) | 160.7 (10.2) | 160.9 (8.8) |
| Weight, kg, mean (SD) | 76.9 (27.1) | 65.7 (15.2) | 80.2 (21.3) | 69.2 (13.1) |
| Education, years, mean (SD) | 10.6 (3.6) | 13.3 (2.5) | 12.4 (4.2) | 13.2 (4.0) |
| Blood pressure mmHg (sBP/dBP), mean (SD) | 139.6/74.7 (22.4/12.3) | 132.1/735 (26.2/10.6) | 131.7/72.1 (20.0/10.2) | 125.5/67.0 (14.9/10.1) |
| Presence of depression, No. (%) | 9 (60.0) | 3 (20.0) | 10 (58.8) | 9 (37.5) |
| Use of Walking aid, No. (%) | 14 (93.3) | 10 (66.7) | 9 (52.9) | 11 (45.8) |
| Independent transfer status, No. (%) | 13 (86.7) | 15 (100) | 13 (76.5) | 23 (95.8) |
| Memory/Thinking Worse[a,e] No. (%) | - | 9 (81.2) | - | 13 (86.7) |
| Memory Worse[b,e] No. (%) | - | 2 (13.3) | - | 7 (29.2) |
| Concern about cognition[c,e], No. (%) | - | 6 (54.5) | - | 7 (46.7) |
| MoCA[d,e], /30, mean (SD) | - | 23.3 (3.1) | - | 21.9 (3.0) |
| **Disease Diagnoses** | | | | |
| Charlson Index Score[f], mean (SD) | 3.7 (1.8) | 2.1 (1.2) | 3.2 (1.5) | 2.5 (1.6) |
| Total number of diagnoses, mean (SD) | 5.9 (3.0) | 5.5 (2.6) | 5.6 (1.8) | 5.4 (3.1) |
| Cardiac Condition, No. (%) | 10 (66.7) | 13 (86.7) | 13 (76.5) | 17 (70.8) |
| Dementia, No. (%) | 10 (66.7) | 1 (6.7) | 11 (64.7) | 7 (29.2) |
| **Medications** | | | | |
| Total number of medications, mean (SD) | 12.6 (5.7) | 10.6 (5.8) | 11.1 (3.7) | 8.0 (3.9) |
| Cardiac condition, No. (%) | 2 (13.3) | 7 (46.7) | 8 (47.1) | 9 (37.5) |
| Mood, No. (%) | 9 (60.0) | 5 (33.3) | 10 (58.8) | 11 (45.8) |
| Dementia, No. (%) | 8 (53.3) | 2 (13.3) | 11 (64.7) | 7 (29.2) |

[a] Do you feel your memory and/or thinking skills has gotten worse recently? (yes or no)
[b] What do you think has gotten worse? Memory, thinking or both
[c] Are you worried/concerned about worsening memory and/or thinking skills? (yes or no)
[d] MoCA = Montreal Cognitive Assessment
[e] Questions and tests were only completed on those without cognitive impairments (i.e. all participants in sites 1 and 3 did not complete cognitive assessments due to prediagnosed impairments).
[f] Charslon Co-morbidity Index Score (Charlson et al., 1987)

For the SSE group only, the average attendance of all participants enrolled was 33.1% (n = 30). The average attendance rate excluding participants who attended zero sessions was 43.2% (n = 23). The average attendance rate of participants with >50% attendance, was 71.0% (n = 10).

In wait-list control group, the average attendance of all participants enrolled was 45.9% (n = 41). The average attendance rate excluding participants who attended zero sessions was 58.8% (n = 31). The average attendance rate of participants with >50% attendance, was 81.3% (n = 20).

## Program Fidelity: Feedback from Kinesiologists

Sites 1 and 2 completed the 12-week

**Table 3: Attendance rates of Square-stepping exercise program at each study site, and attendance rates of other offered exercise programs at each of the sites.**

| Attendance qualities | Site 1 | Site 2 | Site 3 | Site 4 CC[a] | Site 4 LTC[a] |
|---|---|---|---|---|---|
| SSE sessions offered, No. | 19 | 24 | 23 | 24 | 24 |
| Residents at sessions, No. mean (SD) | 5.5 (1.3) | 7.8 (2.7) | 6.4 (2.2) | 9.9 (1.6) | 4.0 (1.3) |
| Participants with >50% attendance, No. | 5 | 6 | 7 | 10 | 3 |
| Attendance Rate %[b], mean (SD) | 77.9 (2.3) | 66.0 (7.6) | 73.3 (17.8) | 87.9 (7.2) | 77.8 (15.3) |
| Participants with 1-50% attendance, No. | 6 | 6 | 5 | 3 | 4 |
| Dropouts or 0% attendance, No. | 4 | 3 | 5 | 4 | 0 |
| Residents who tried SSE but not enrolled, No. | 2 | 13 | 0 | 2 | 2 |
| Attendance rate of physical activity programs at sites[c] | 7.8 (2.0) | 6.7 (1.9) | 12.0 (6.3) | 6.1 (3.8) | - |

[a] Continuum care (CC) and long-term care (LTC) at site 4 completed the square-stepping program as separate groups and are reported as such.
[b] Attendance rates based on participants with >50% attendance
[c] Data provided by Schlegel Villages; values represent the average attendance rates of physical activity programs that are normally offered at each of the sites by kinesiologists during the intervention period (July-September 2017).

SSE program first (July – September 2016), which was the first time SSE was implemented in LTC or CC environments, and thus feedback from these sites prompted changes for SSE implementation in the wait-list sites, sites 3 and 4 (November 2016 – January 2017).

### Site 1: long-term care home in SSE group

Site 1 was a LTC home with one kinesiologist employed in addition to a kinesiology student assisting throughout the duration of the SSE program. The kinesiologist decreased the duration of each session from 60 minutes to 45 minutes to maintain engagement of participants, and altered the program progression; the kinesiologist reported:

We will often bounce around throughout the beginner series within a class if we are seeing loss of interest (not complete them in sequential order) and we know the [patterns that the participants] always do well on and so we will go back and complete one of those [patterns] if the group is struggling (source of information: email).

The kinesiologist at site 1 found the SSE to increase physical activity and social engagement, and conveyed:

… we are seeing some great improvement in a few residents that are participating with us, both socially and physically… some residents that will simply join for some extra walking as they were not picking up the patterns at all. The residents that could follow did amazingly well and they were great at coaching the others (source of information: email).

### Site 2: Continuum care in SSE group

Site 2 had two kinesiologists, one

assigned to RL and one assigned to LTC. The kinesiologists found that repeating each pattern four times, as per the SSE protocol, was too much because of the range of cognitive abilities, and therefore reduced the number of repetitions to two. Participants with higher cognitive function provided peer support by becoming SSE coaches to support the participants with cognitive impairments (source of information: phone call discussion).

The wait-list control sites, 3 and 4, began the program with the changes that sites 1 and 2 implemented (i.e., 45 minutes duration) and encouraged participants to become peer coaches.

**Site 3: Long-term care home in wait-list control group**

At site 3, there were two kinesiologists working at this LTC home. At 4-weeks into the program one kinesiologist reported on the positive social aspects of the program:

…They like being in this group and they are very supportive of each other. The [participants with higher cognitive function] are stepping up and helping to coach the [participants] that are finding it challenging... everyone cheers for them (source of information: email).

Site 3 found that participants continued to be engaged despite declining function and increased use of the hand SSE mat; the kinesiologist relayed:

…we noticed several [participants] declined, their dementia progressed, one fractured a hip, another became more unsteady on her feet. This resulted in 4-5 [participants] using the finger board. They work well together and are very encouraging to each other, so socially it has been a good experience for the residents (source of information: email).

**Site 4: Continuum care in wait-list control group**

Similar to site 2, site 4 had two kinesiologists, where one kinesiologist was assigned to RL and one kinesiologist was assigned to LTC. At this site, the kinesiologists chose to separate the residents into two SSE groups based on their level of care.

In the LTC group, a volunteer assisted the kinesiologist at all the sessions. The kinesiologist did not follow the patterns in sequential order, but rather chose patterns that the participants could do and enjoyed. The residents adopted peer coaching on their own, which fostered a supportive group dynamic (source of information: in person).

A kinesiologist and volunteer completed the SSE program in the retirement living side of site 4; they reported that the participants enjoyed the social aspect of the program, and they found it to be an encouraging group and the participants' circle of friends was widened by meeting new people in the program. Anecdotally, several participants reported they felt that their balance improved, and one resident began using walking poles instead of a walker (source of information: in person).

**Feasibility of the outcome measurements**

There was vast variability in cognitive and mobility impairments and thus, participants completed assessments as they were able, regardless of their diagnoses (see Supplementary Table 3). This created variability in the number of participants who completed each assessment.

### Mood and Behaviour Questionnaire

The participants with dementia in the SSE group improved in the NPIQ total, ($F(23) = 7.3$, $p = 0.01$, $\eta_p^2 = 0.25$); frequency, ($F(23) = 9.4$, $p = 0.01$, $\eta_p^2 = 0.30$) and severity, ($F(23) = 7.0$, $p = 0.02$, $\eta_p^2 = 0.24$), scores at V1 compared to the control group (those with dementia), controlling for V0 (See Figure 1). Exploratory chi-square analyses were conducted to identify which of the 12 questions were improved upon. It was found that the SSE group demonstrated reduced delusions, [$X^2 = 4.2$, $p = 0.04$ (SSE group 0%; Control group 33%)], dysphoria/depression, [$X^2 = 5.2$, $p = 0.03$ (SSE group 20%; Control group 67%)] and disinhibition, [$X^2 = 3.7$, $p = 0.05$ (SSE group 10%; Control group 47%)] compared to the control group at V1.

### Cognition

No differences were seen at V1 between groups controlling for baseline in GCF, memory, planning, reasoning, or concentration (all $F<1$, $p>0.05$; SSE group, n = 11, Control group, n = 10) (See Figure 2).

In exploratory analyses, level of care was added as factor in our model, that is, a 2 (group) x 2 (level of care) model; however, no differences were found in level of care at V1, when adjusting for baseline.

In further exploratory analyses, sex was added as a factor in our model, that is, a 2 (group) x 2 (sex) model, adjusting for baseline score, age, and years of education. In the planning domain model an interaction was found ($F = 7.7$, $p = 0.02$, $\eta_p^2 = 0.35$), with main effects of group ($F = 6.6$, $p = 0.02$, $\eta_p^2 = 0.32$) and sex, ($F = 13.4$, $p<0.01$, $\eta_p^2 = 0.49$), favouring the SSE group and females respectively. In the concentration domain model an interaction was also found ($F = 5.6$, $p = 0.03$, $\eta_p^2 = 0.29$); however, no main effects were significant. Descriptively, males had lower mean z-

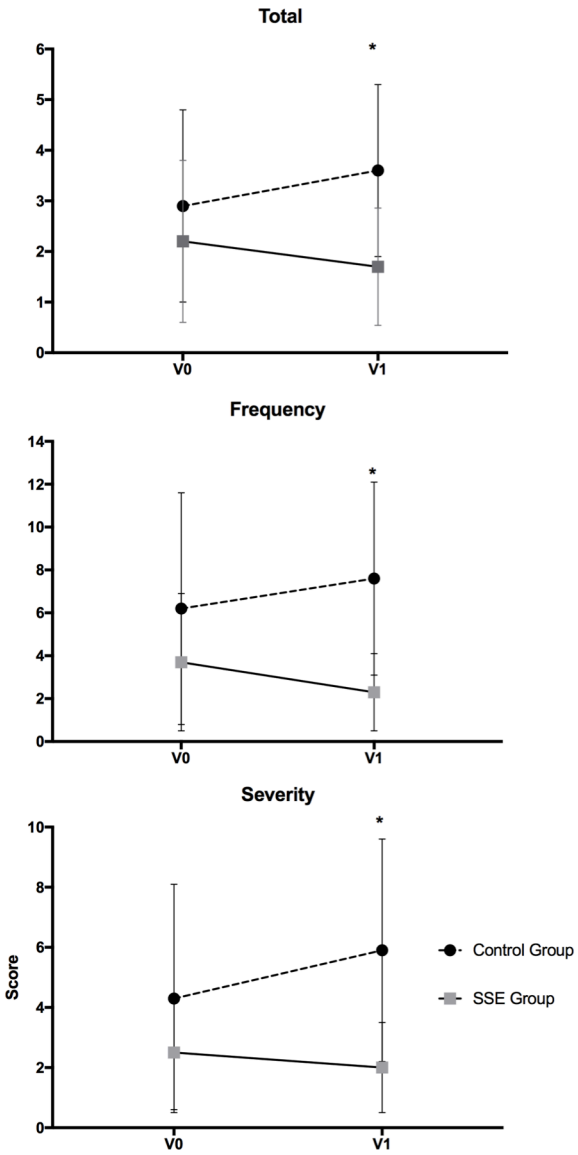


**Figure 1: Neuropsychiatric Inventory Questionnaire (NPIQ) mean scores with standard deviations for total score, frequency score and severity score, separated by randomization group (Circles = control group; squares = Square-stepping exercise group (SSE) group). Lower scores represent less affliction of mood and behaviours. SSE group, n=10; Control group, n=15. * Represents statistically significant difference between groups at V1, controlling for baseline.**

scores for all domains and GCF at all time points. Within sex analyses did not reveal between group differences in GCF. Regardless of group assignment, females had higher planning domain z-scores at V1 compared to males, controlling for V0 ($F = 5.1$, $p = 0.04$ and $\eta_p^2 = 0.22$); however, no other domains were

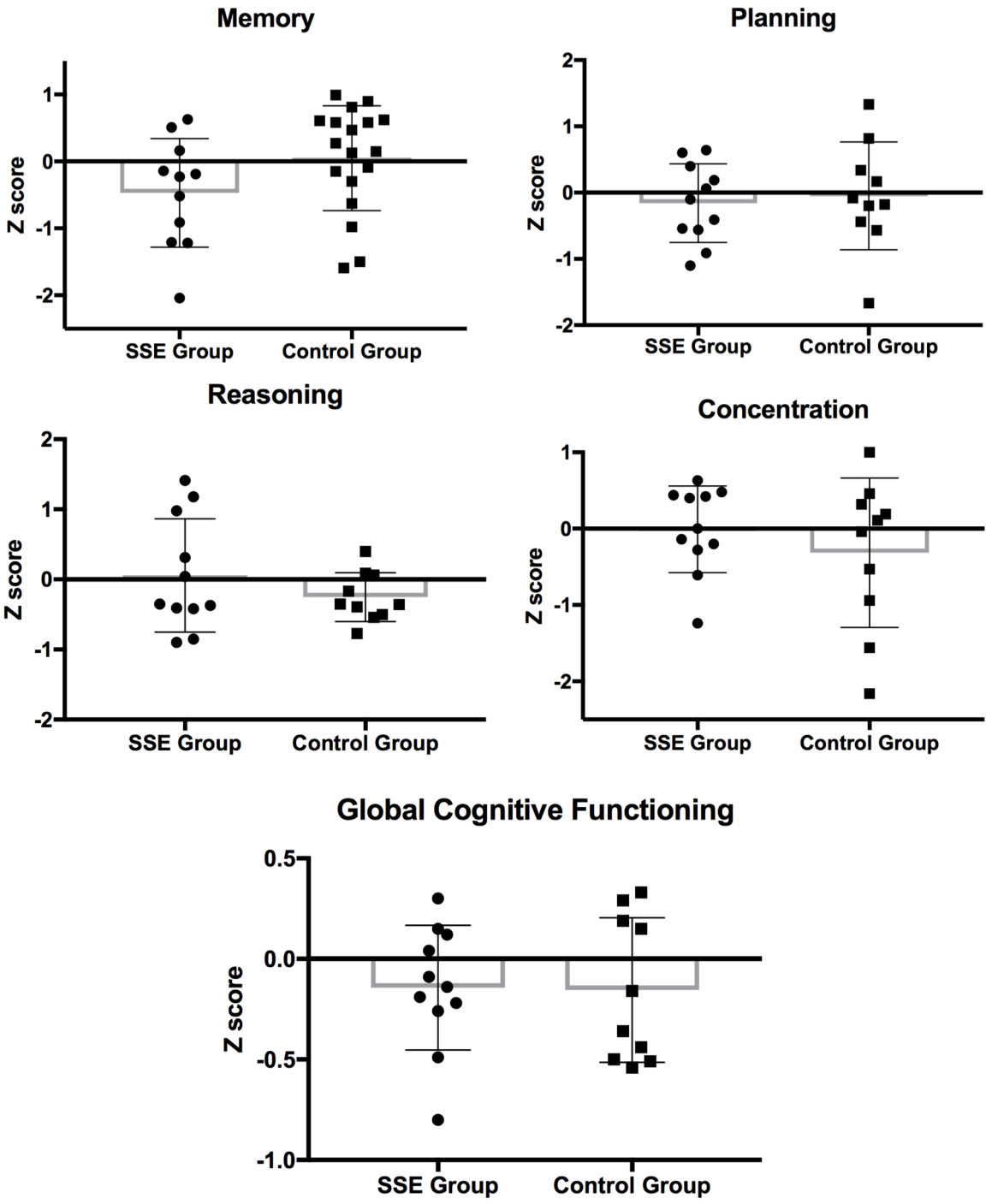


**Figure 2: Boxes with error bars represent mean change in cognitive outcomes (standardized z-scores) by randomization group; circles represent indiviual change score in Square-stepping exercise (SSE) group and squares represent individual change scores in control group for each cognitive domain, V0-V1.**

significant.

The mean scores of CBS are reported with population norms for adults 75-90 years of age as reference population (See Supplementary Table 4). Results remained similar in sensitivity analyses.

## Adverse Events

There were no adverse events reported.

## Discussion

### Feasibility of SSE

Of all those enrolled in the study, the average attendance rate was only 40.5% which demonstrates issues with feasibility of SSE in diverse groups. It was noted that the mean attendance rate for the participants who were committed to the program (i.e., attended more than 50% of sessions) was 77%. This may indicate that a proportion of the group, specifically those in retirement living rather than long-term care attended more sessions. Further, the attendance records demonstrated that participants with low attendance rates generally came to a few sessions at the beginning of the program, lost interest and discontinued participation in the sessions. This allowed the participants with higher attendance rates to foster supportive peer coaching relationships and engage socially with one another throughout the 12-weeks, as demonstrated through the feedback from the kinesiologists. There is little research that measures social interaction as a part of an intervention; however, it is known that low social contacts and loneliness are related to increased risk of dementia and Alzheimer's disease (Bellou et al., 2017; Shankar et al., 2013). Therefore, maintaining good social networks is important for maintained cognition, which SSE may provide.

It is not surprising that the participants did not have perfect attendance because many of the residents have co-morbid chronic diseases, cognitive and mobility impairments, which generally worsen with increasing age. This was demonstrated through the Charlson Co-morbidity Index score, which indicated the participants had a chronic disease burden of nearly three, which would be expected for adults living in CC and LTC homes. The attendance rates observed here were lower than previously published intervention trials of similar length, citing rates 58 – 92%, which further demonstrated that SSE has limited feasibility in LTC and CC homes (Anderson-Hanley et al., 2012; Brown et al., 2009; Johnson et al., 2013). However, the number of participants attending the SSE sessions was similar to residents who attended other regularly offered exercise programs at the sites by the kinesiologists. The villages and RIA anecdotally acknowledged that this study was simple to recruit for, in comparison to other research studies conducted at their homes. Overall, our 12-week study of SSE in CC and LTC homes demonstrated limited feasibility for older adults with diverse cognitive and mobility impairments in LTC and RL homes. However, the program was met with positive attitudes of the external stakeholders (i.e., Schlegel Villages and RIA). Recommended modifications by the kinesiologists for diverse populations include: 1) 45 minutes per session, 2) instruction with at least one kinesiologist in RL and two kinesiologists in LTC, 3) peer coaching should be fostered, 4) volunteers should be recruited, and 5) pattern progression should be tailored to individuals participating. Additionally, it was suggested by SSE developer and co-author, RS, to provide written instructions of the patterns for

individuals with cognitive impairments to improve confidence in completing the patterns and enjoyment of the program, which may improve the feasibility of SSE in LTC homes.

**Outcome Assessments**

A 12-week SSE program can improve the mood and behaviours of participants living with dementia, specifically delusions, depression, and disinhibition. Mood and behaviours symptoms in adults living with dementia are associated with reduced quality of life (Beerens et al., 2013) and thus, improving these symptoms may increase quality of life through a SSE program. We cannot identify a specific mechanism for this change, as it is likely multifactorial. Further, because the questionnaire was administered by caregivers within the homes there is the possibility of bias within this measure. However, we are confident that the bias did not impact our positive result in this study due to: the nature of the questionnaire, its reliance on the awareness of participants behaviours, administration of the questionnaire recommended to be completed by a close caregiver, and its demonstrated validity, (Cummings et al., 1994). Therefore, this evidence provides support for the benefits of cognitive stimulation and social interaction for people living with dementia in LTC with high chronic disease burden.

We did not see any differences between groups in cognition (GCF, memory, planning, concentration, or reasoning) following the 12-week SSE as measured by the CBS games. This may be due to several factors related to the feasibility, which may include the SSE program, the CBS games, and/or the population recruited. In administering the CBS games, we found limited feasibility in the current population, which resulted from: cognitive fatigue, lack of familiarity with computers, and visual fatigue from the computer monitor. The SSE program is a cognitive training program rather than aerobic exercise as well as 12-weeks in duration, which may not have been a high enough intensity or long enough duration to elicit cognitive changes in a population with diverse cognitive function. Previous literature has indicated that a 6-month, moderate intensity program may be required for cognitive change (Colcombe & Kramer, 2003); however, we felt 12-weeks was an appropriate length for a pilot feasibility study in LTC and CC homes. Additionally, we did not control the amount of exercise or cognitive training the participants did outside of the program and it is possible that the control group was equally engaged during the intervention period and thus we did not see an effect. It is likely a combination of factors that led to our null result.

Overall, we found there to be a lot of variability in the number of participants who completed each assessment. It is likely related to high disease burden and therefore, we conclude that the feasibility of the assessments is limited in this setting (LTC and CC homes) because they were individualized to each participant's cognitive ability and mobility impairments.

**Limitations**

A limitation in assessing the feasibility of the SSE program in LTC and CC homes was that we did not conduct formal recorded interviews with the kinesiologists and thus, we were unable to conduct qualitative theme-based analyses. Formal interviews and analyses may have led to a better understanding of the social relationships formed between

residents and themes related to program modifications for diverse groups and environments. In analyzing the results of this pilot study, we found that there is vast variability in our study population; the mean age was 81.7 years with a range of 38-100 years, which encompassed a vast array and combination of chronic disease and mobility impairments, as noted in the Charlson Co-morbidity Index scores. Therefore, a second limitation of the study was the variability in our study sample, which likely limited our ability to assess the effects of the program, in addition to the variability added by incorporating a hand SSE mat for individuals with mobility impairments, which likely impacted the evaluation of feasibility. However, our goal was to assess the feasibility of the SSE program in a wide sample, and therefore we will be able to alter for future implementation trials. A potential third limitation would be bias at site 1; we conducted initial pilot work in August 2014 and a few residents had brief exposure to SSE. This initial pilot work led to the Mind-fun Study that we are reporting on. Another limitation to the study was having the kinesiologsts complete the NPIQ with the residents, which introduced bias in its results. Due to the nature of the questionnaire and its reliance on the awareness of participants' behaviours it should be noted for future studies to have a third party or blind the evaluator to reduce potential bias (i.e., another caregiver; family member etc.).

The variability described above would be seen in almost any LTC and CC home in Ontario and thus is likely a representative sample. Without exclusion criteria we had little way of controlling for cognitive ability. If we had a larger sample, more sites or larger capacity to implement the program, we may have been able to control more variables in our analyses, and thus see trends in our outcomes. This would help to determine if SSE is effective in a diverse population.

## Conclusions

SSE has limited feasibility as a cognitive training program in a diverse group in LTC and CC homes as shown through low recruitment and attendance rates. However, we demonstrated that the program can be easily modified and tailored to specific populations. In addition, all sites have expressed interest in continuing SSE as a part of their regular programming, which demonstrates its role as a challenging and social program. Lastly, we demonstrated the benefits of SSE for residents living with dementia with improved mood and behaviour symptoms. The effects on cognition remain equivocal. SSE should be further explored in more homogenous populations.

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## Authors' Qualifications

The authors' qualifications are as follows: Erin M. Shellington PhD, MSc; Dawn P. Gill PhD; Kaylen Pfisterer PhD(c), MSc; Susan Brown MSc; Jaimie Killingbeck BSc. R.Kin; P. Karen Simmavong MA; Andrea F. Petrella BA, MSc(c); Narlon C. Boa Sorte Silva BSc; Ryosuke Shigematsu PhD; and Robert J. Petrella MD, PhD

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**Supplementary Table 1: Descriptions of Cambridge Brain Sciences cognitive battery games.**

| Game Name | Brief description of game |
|---|---|
| **Memory** | |
| **Monkey Ladder** | Sets of numbered squares are displayed all at the same time at random locations within an invisible 5*5 grid. After a variable interval, the numbers are removed leaving just the blank squares visible and a tone cues the participant to respond by clicking on the squares in ascending numerical sequence. After 3 errors the test ends. |
| **Digit Span** | Participants view a sequence of digits that appear on the screen one after another. Subsequently, they repeat the sequence of numbers by entering them on the keyboard. After 3 errors the test ends. |
| **Planning** | |
| **Hampshire tree task** | Numbered beads are positioned on a tree shaped frame. The participant repositions the beads so that they are configured in ascending numerical order running from left to right and top to bottom of the tree, solving as many problems as possible in 3 minutes. |
| **Spatial Search** | Sets of boxes are displayed on the screen in random locations within an invisible 5*5 grid. The participant must find a hidden "token" by clicking on the boxes one at a time to reveal their contents. When the token is found, it is hidden within another box. After 3 errors the test ends. |
| **Reasoning** | |
| **Double Trouble** | A coloured word is displayed at the top of the screen, for example the word RED drawn in blue ink. The participants must indicate which of two coloured words at the bottom of the screen describes the colour that the word at the top of the screen is drawn in. The colour word mappings may be congruent, incongruent, or doubly incongruent, depending on whether or not the colour that a given word describes matches the colour that it is drawn in, solving as many problems as possible within 90 seconds. |
| **Odd One Out** | A 3* 3 grid of cells is displayed on the screen. Each cell contains a variable number of copies of a coloured shape. The features that make up the objects in each cell (color, shape, number of copies) are related to each other according to a set of rules. The participant must deduce the rules that relate the object features and select the one cell whose contents do not correspond to those rules, solving as many problems as possible in 3 minutes. |
| **Concentration** | |
| **Polygon Task** | A pair of overlapping polygons is displayed on one side of the screen. To gain maximum points, the participant must indicate whether a polygon displayed on the other side of the screen is identical to one of the interlocking polygons, solving as many problems as possible within 90 seconds. |
| **Rotations Task** | In this variant, two grids of coloured squares are displayed to either side of the screen with one of the grids rotated by a multiple of 90 degrees. When rotated, the grids are either identical or differ by the position of just one square. To gain maximum points, the participant must indicate whether the grids are identical, solving as many problems as possible within 90 seconds. |

**Supplementary Table 2: Participant baseline characteristics, by randomization group.**

| | Control Group (n = 41) | SSE Group (n = 30) |
|---|---|---|
| **Age, years,** mean (SD) | 82.6 (10.0) | 80.5 (12.2) |
| **Female sex,** No. (%) | 30 (73.2) | 23 (76.7) |
| **Married,** No. (%) | 13 (31.7) | 11 (36.7) |
| **Caucasian,** No. (%) | 38 (92.7) | 29 (96.7) |
| **Height, cm,** mean (SD) | 160.8 (9.3) | 159.3 (10.5) |
| **Weight, kg,** mean (SD) | 73.8 (17.9) | 71.3 (22.4) |
| **Education, yr,** mean (SD) | 12.9 (4.0) | 12.2 (3.2) |
| **Blood pressure mmHg,** mean (SD) | 128.0/69.1 (17.2/10.3) | 135.9/74.1 (24.3/11.3) |
| **Presence of depression,** No. (%) | 19 (46.3) | 12 (40.0) |
| **Use of Walking aid,** No. (%) | 20 (48.8) | 24 (80.0) |
| **Independent transfer status,** No. (%) | 36 (87.8) | 28 (93.3) |
| **Memory/Thinking Worse**[a] No. (%) | 13 (86.7) | 9 (81.2) |
| **Memory Worse**[b] No. (%) | 7 (29.2) | 2 (13.3) |
| **Concern about cognition**[c], No. (%) | 7 (46.7) | 6 (54.5) |
| **MoCA**[d], **/30,** mean (SD) | 21.9 (3.0) | 23.3 (3.1) |
| **Charlson Index Score**[e], Mean (SD) | 2.9 (1.7) | 2.8 (1.6) |
| **Total number of diagnoses,** mean (SD) | 5.5 (2.6) | 5.7 (2.7) |
| **Total number of medications,** mean (SD) | 9.3 (4.1) | 11.6 (5.7) |

[a] Do you feel your memory and/or thinking skills has gotten worse recently? (yes or no)
[b] What do you think has gotten worse? Memory, thinking or both; memory only reported
[c] Are you worried/concerned about worsening memory and/or thinking skills? (yes or no)
[d] MoCA = Montreal Cognitive Assessment
[e] Charlson Comorbidity Index Score (Charlson et al., 1987)

**Supplementary Table 3: The number of participants that completed each outcome assessment at baseline (V0) and post-intervention (V1).**

| Outcome | Timepoint | Site 1 (n=15) | Site 2 (n=15) | Site 3 (n=17) | Site 4 (n=24) | Total (n=71) |
|---|---|---|---|---|---|---|
| **Global Cognitive Functioning**[a] | V0 | 4 | 10 | 2 | 13 | 29 |
| | V1 | 1 | 10 | 1 | 11 | 23 |
| Monkey Ladder | V0 | 4 | 10 | 7 | 15 | 36 |
| | V1 | 1 | 10 | 5 | 13 | 29 |
| Digit Span | V0 | 4 | 10 | 7 | 15 | 36 |
| | V1 | 1 | 10 | 5 | 13 | 29 |
| Hampshire Tree Task | V0 | 4 | 10 | 5 | 15 | 34 |
| | V1 | 1 | 10 | 5 | 12 | 28 |
| Double Trouble | V0 | 4 | 10 | 2 | 15 | 31 |
| | V1 | 1 | 10 | 2 | 12 | 25 |
| Interlocking Polygons | V0 | 4 | 10 | 2 | 15 | 31 |
| | V1 | 1 | 10 | 1 | 12 | 24 |
| Token Search | V0 | 4 | 10 | 2 | 13 | 29 |
| | V1 | 1 | 10 | 1 | 11 | 23 |
| Odd One Out | V0 | 4 | 10 | 2 | 13 | 29 |
| | V1 | 1 | 10 | 1 | 11 | 23 |
| Rotations Task | V0 | 4 | 10 | 2 | 13 | 30 |
| | V1 | 1 | 10 | 1 | 11 | 23 |
| **NPIQ**[b] | V0 | 10 | 2 | 9 | 6 | 27 |
| | V1 | 8 | 2 | 9 | 6 | 25 |

[a] Global cognitive functioning is created through a composite of the 8 games
[b]NPIQ is the Neuropsychiatric Inventory Questionnaire.

**Supplementary Table 4: Randomization group mean scores of Cambridge Brain Sciences games at baseline and normative population values for older adults.**

| Game name, mean (SD) | Control Group | SSE Group | Population norms[a] |
|---|---|---|---|
| **Memory: Monkey Ladder** | 4.5 (1.9) n = 22 | 5.0 (1.5) n = 14 | 6.1 (1.7) n = 243 |
| **Memory: Digit Span** | 3.9 (1.7) n = 22 | 4.4 (1.5) n=14 | 6.5 (1.7) n = 246 |
| **Planning: Hampshire Tree task** | 8.8 (5.0) n = 20 | 8.7 (5.7) n = 14 | 13.8 (9.7) n = 215 |
| **Reasoning: Double Trouble** | 4.6 (6.6) n = 17 | 4.0 (7.4) n = 14 | 15.5 (14.8) n = 249 |
| **Concentration: Interlocking polygons** | 11.6 (13.6) n = 17 | 15.9 (17.5) n = 14 | 30.6 (21.6) n = 248 |
| **Planning: Token Search** | 4.5 (1.7) n = 15 | 4.7 (0.9) n = 14 | 5.8 (2.2) n = 241 |
| **Reasoning: Odd one out** | 7.3 (4.2) n = 15 | 6.7 (4.2) n = 14 | 8.9 (4.2) n = 243 |
| **Concentration: Rotations task** | 37.9 (37.6) n = 15 | 40.8 (34.0) n = 14 | 62.2 (32.8) n = 246 |

[a]Population norms for adults 75-90 years old from www.cambridgebrainsciences.com.