

# Effect of physical activity among seniors participating in a cognitive health promotion program

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## Abstract

**Background:** Several studies have demonstrated that physical activity (PA) could have an impact on the cognitive vitality of older adults. The Jog Your Mind program encourages participants to become more physically active and is designed to promote cognitive vitality. This study aims to explore: 1) the effect of the program on PA; 2) the moderating and mediating effects of PA on the program's impact on cognition; and 3) the correlation between PA and various cognitive domains in participants prior to the start of the program.

**Methods:** In total, 294 individuals aged 60 and over participated in the cognitive vitality promotion program immediately for the experimental group or one year later for the controls. They were evaluated using cognitive tests, questionnaires (MoCA, MIA, CVLT, RBMT, MMQ, QAA, Stroop) and PA instruments (an adapted version of the CHAMPS physical activity questionnaire and the 2-minute step test). Correlations were made at the start of the study and multiple regressions were carried out to measure the impact of the program on PA.

**Results:** Participation in the program was associated with an increase in PA ( $p < 0.05$ ). However, analyses did not show a significant moderating or mediating effect of PA on cognition ( $p < 0.05$ ). At the start of the study, the most active subjects obtained better results in terms of memory strategies ( $p < 0.05$ ).

**Conclusions:** These results show that a multifactorial program, including the promotion of PA, can lead participants to become more physically active. Further studies should be implemented to determine whether the practice of PA has a moderating or mediating effect on cognitive vitality.

**Citation:** Desgagnés-Cyr C-E, Bier N, Parisien M, Nour K, Auger L-P, Fournier B, Laforest S (2015) Effect of physical activity among seniors participating in a cognitive health promotion program. *Healthy Aging Research* 4:25. doi:10.12715/har.2015.4.25

**Received:** December 31, 2014; **Accepted:** March 2, 2015; **Published:** April 17, 2015

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**Competing interests:** The authors have declared that no competing interests exist.

**Sources of funding:** This project was funded by the Canadian Institutes of Health Research (CIHR) (MOP 102 545).

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## Introduction

Aging is accompanied by progressive changes in cognitive vitality, which can have a considerable impact on an individual's quality of life and survival [1, 2]. The concept of cognitive vitality is comparable to the term "cognitive health". This is described as "the development and preservation of the

multidimensional cognitive structure that allows the older adult to maintain social connectedness; an ongoing sense of purpose; the ability to function independently; to permit functional recovery from illness or injury and cope with residual functional deficits" [3].

Maintenance of optimal health (including cognitive vitality) in older adults is an important issue in our society. There is a wealth of scientific literature pertaining to the role of healthy lifestyle habits in this regard [4]. For example, engaging in recommended amounts of physical activity (PA) can reduce the risk of chronic disease [5-8] and premature death [6, 7, 9]; help maintain independence and mobility [5, 6, 10]; improve physical fitness [11], body mass, bone health and cognitive function [9, 12, 13]. To achieve these benefits, current recommendations are to practice between 150 and 300 minutes of PA per week [9, 14-17], which are divided into periods of 20 to 30 minutes of activity per day. This activity is to be carried out at least 5 days a week, at a moderate intensity.

In terms of cognitive health, certain studies have observed the effects of physical training programs; however, further studies are required to explore specific PA factors that improve cognitive function in older adults [11]. To date, physical training has been specifically shown to improve certain aspects of cognitive function in this population [18-20] and to prevent the emergence of dementia [13, 21-25]. Two types of physical training have been extensively studied: aerobic and resistance exercise training.

The first type of physical training, moderate-intensity aerobic exercise, has been demonstrated to lead to a series of physiological adaptations [12, 26-29]; enhancing neurogenesis [30] and the proliferation, survival, differentiation and performance of neurons [31]. These changes are believed to lower the risk of dementia and cognitive decline [13, 27, 31, 32], promote cerebrovascular integrity and improve brain plasticity [27, 29, 31, 33, 34]. Aerobic exercise helps to preserve neurons in the hippocampus [33, 35] and in the frontal, parietal and temporal lobes [31, 33]. All of these physiological changes have been shown to translate into notable improvements in certain cognitive domains such as; processing speed [26], recall [26, 28, 36]; visual attention [26, 28, 36]; auditory attention [26]; reaction time [18, 33, 37], judgement [33] and working memory [33]. However, Angevaren et al [26] notes that although aerobic activity clearly results in improvements in certain cognitive domains, a number of studies on the same subject have not yielded significant results [26, 38](see reviews by Angevaren and Etner).

The second type of physical training, resistance training, leads to an increase IGF-1 levels in the brain of older adults, resulting in improved blood flow and viscosity [28]. This type of exercise also increases neuro-electric activity [28, 31] and enhances the generation, survival, differentiation and performance of neurons [31]. Resistance exercise is also beneficial for short-term memory, executive functions [28, 36], attention [28, 36, 39] and cognitive processing speed [28, 33, 36].

Interestingly, it appears that a combination of aerobic and resistance training has an even greater benefit for certain cognitive domains than when each training method is practiced separately [4, 20, 35]. A variety in types of PA, in addition to the frequency and volume of activity (minutes per week), could therefore be an important factor in the overall health and cognitive vitality of older adults [40]. However, some authors point to a lack of details and specific recommendations regarding volume, frequency, diversity and intensity of PA [41, 42], which would provide a complete set of recommendations to older adults seeking to use PA as a strategy to maintain their cognitive health.

Studies on physical training and cognition have however yielded insignificant or mixed results [5, 28, 43, 44]. Others showed indirect links between PA and cognition [45]. Paterson et al [5] suggest that these contradictory results may, in part, be explained by the excessive variability in the tools employed to measure cognitive function.

The specific mechanism that links PA with cognition – PA as a moderator or a mediator – also remains to be elucidated. The literature suggests that the practice of PA can have moderating effects [11, 64-69], or even mediating effects [70] on cognition, and could therefore potentially have the same effects on a cognition program. Bherer et al [11] report results from cross-sectional studies with healthy older adults, in which PA played a moderating role in cognitive function. In other words, PA led to a greater maintenance of cognitive functions among older adults who were very active at the beginning when compared to less active seniors, over a given period [71, 72]. Longitudinal studies have shown diminished cognitive decline after 2 to 10 years among active subjects [66, 73]. Finally, intervention studies with a

sufficiently high duration, intensity and frequency of PA have shown improvements in cognitive performance [20, 74]. The mediating effects of PA have been noted in several studies and reviews on cognitive health and quality of life [70, 75]. These studies have examined whether cognitive health and quality of life are dependent on, or influenced by a variation in the practice of PA over time, and to what extent. For example, Sawatzky's study aimed to measure the degree to which "the negative impact of chronic conditions on quality of life and important health outcomes (dexterity, mobility, pain, cognition, and emotional wellbeing) in older adults can be attributed to a lack of physical activity" [70]. The author concluded that "physical activity partially mediates the impact of chronic conditions on several health outcomes that are important to quality of life" [70] without, however, obtaining significant values in terms of cognition. Researchers have noted the limitations of self-reported PA measures (volume of leisure activities) as a way to further gauge the mediating effects of PA. In short, several authors suggest that PA could have a moderating or even mediating effect on cognition, and therefore potentially on the effects of a cognition program.

Another way to improve cognition in older adults is through non-physical group activities. Multiple studies have shown the effectiveness of this type of approach on the cognition of older adults who experience a normal aging process. The best-known studies of this type are generally focused on training cognitive functions such as memory, attention and problem-solving [46-48]. Some also include a psychosocial component including strategies aimed at improving participants' confidence in their cognitive capacities [49-52]. Others are more orientated toward stress management [53], promotion of a balanced diet [54], and the social and intellectual engagement of participants [55,56]. However, to our knowledge, no studies have been identified that integrate all of these components into one multifactorial approach that is also aimed at engaging participants in stimulating activities and PA. Some authors have studied the additional effects of PA in combination with cognitive exercises in different populations [19, 54, 57-63]. All of the above authors, with the exception of Legault et al [59], obtained significantly improved outcomes when both types of training were combined.

Nonetheless, many important aspects remain to be studied. Hence, the effects of a multifactorial approach aimed at promoting PA that also measured the effects of these efforts to promote PA following the program has not been studied to date. There are also no study exploring the positive combined effects of PA and cognition in the context of a multifactorial cognitive program that promotes the practice of PA without direct intervention. Finally, the impacts of free and voluntary practice of PA on cognition as not been studied to date.

Jog Your Mind is a multifactorial program created by a multidisciplinary team of researchers and health practitioners, aimed at promoting cognitive health in older adults [76]. Taking the form of a group workshop, Jog Your Mind includes cognitive stimulation activities, memory strategy exercises, and tools to promote self-efficacy and encourage lifestyle habits related to cognitive health (e.g., independent walking). The program targets a population of seniors who are experiencing normal cognitive aging. This program can be offered in a community setting, by workers who have no specific expertise in cognition such as, recreation practitioners and volunteers trained to lead group activities. The program consists of 10 two-hour sessions for groups of 10 to 15 people. The third session is focused on promoting PA (all subsequent sessions include 10-minute segments on PA). The main strategies used to promote PA and, more specifically, walking are: personal reflection using a questionnaire on sources of motivation; group discussions on elements facilitating walking; the loan of pedometers; the sharing of neighbourhood resources for PA (e.g., safe walking trails); the transmission of information in the form of games and quizzes and the formulation of a personal PA goal.

The objectives of this study were: 1) to verify the impact of a cognitive vitality program on participants' practice of PA; 2) to study the moderating and mediating effects of PA on the program's impact on cognition; and 3) to explore the correlation between the practice of PA and various aspects of cognitive vitality measured at the start of the study. We anticipated that following the program participants in the experimental groups would have significantly increased their practice of PA in terms of duration, variety and frequency, while those in the control group would not have modified their practice. In

terms of our second objective, we anticipated that PA would have a moderating, but not a mediating effect on cognition, as has been previously reported [70]. We therefore hypothesized that participants' PA level at baseline would affect the program's impact on cognition (moderating effect)—in other words, that the most active participants would benefit the most from the program and would enjoy improved cognitive vitality following the program. However, we did not think that the benefits resulting from participation in the Jog Your Mind program, at the cognitive level, would be dependent on a positive variation in PA (mediating effect). For our third objective, we hypothesized that the volume (minutes), frequency and variety of physical activities would be significantly correlated with certain aspects of cognitive vitality.

## Methods

This study is part of a quasi-experimental research project, with a control group on a one-year waiting list, aimed at assessing the effects of the Jog Your Mind program. The bulk of the research was carried out between 2009 and 2013 in Quebec, Canada, and the control and experimental groups were matched for one year in order to account for the different seasons. This study included three periods of measurement, the methodology has been described previously [77]. For the present study, only data from two measurement periods were used. The pre- and post-test data were used to study the effects of the program on the practice of PA ( $n=271$ ), while the pre-test data were used to conduct a cross-sectional analysis of the correlations between the practice of PA and cognitive vitality ( $n=294$ ). Fig. 1 shows the study design and flow of participants through each stage.

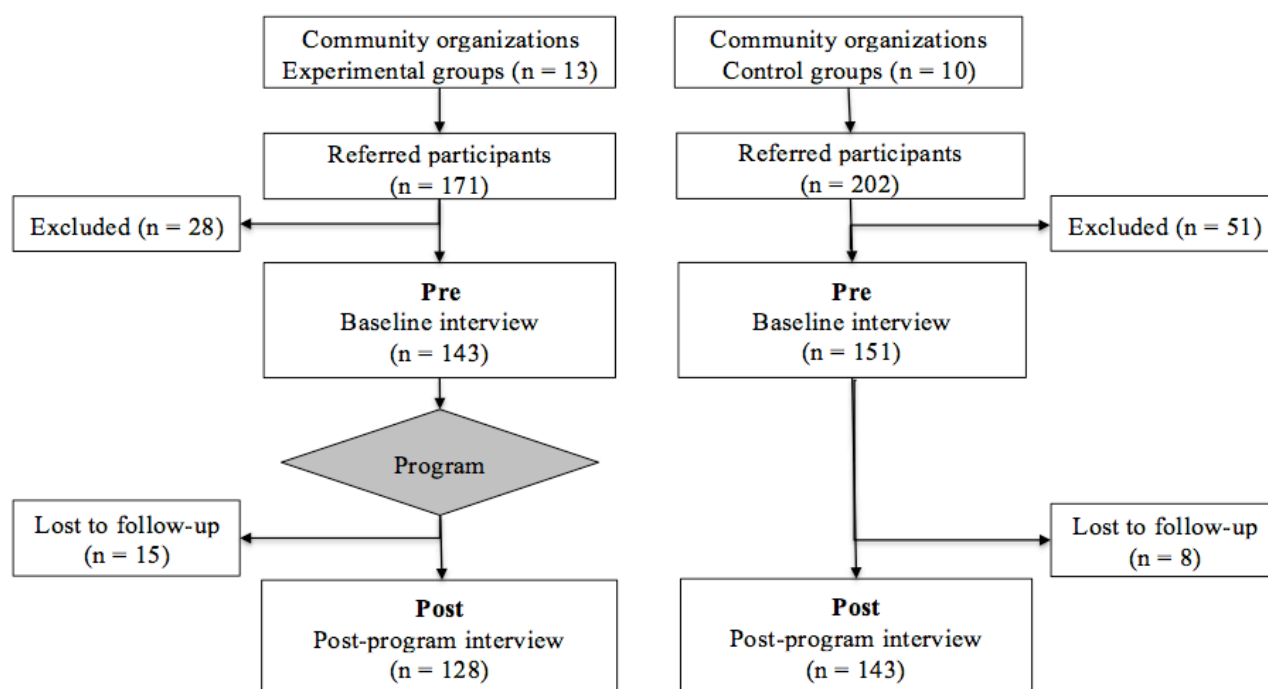


Figure 1. Study design



## Population and recruitment

Twenty-three community organizations in Greater Montreal agreed to collaborate on a multi-site study and each recruit 15 seniors. For inclusion in the main study, the participants had to meet several criteria: 1) to be aged 60 or over; 2) speak French; 3) agree to participate in a study over a period of one year; 4) to be interested in participating in a workshop promoting cognitive vitality, involving one 2-hour meeting per week over 10 weeks; 5) could not have followed a similar program in the year prior to their participation in this study; 6) could not have received a diagnosis for cognitive impairment. The organizations had a selection chart to help them recruit subjects. This program was publicized through their regular communication channels such as; seniors' activity calendars; ads in local newspapers and presentations. Thirteen groups offered the program the first year (experimental groups), and ten agreed to wait a year before offering the program (control groups).

## Data collection

The community organizations forwarded the names of participants to the research coordinator who verified their eligibility and interest. A trained interviewer administered a closed questionnaire to participants, as well as tests lasting 90 minutes in the facilities of the community organizations (pre-test). Participants signed a consent form for the study and a Research Ethics Board certificate from the Université de Montréal had previously been obtained. Three months later, at the end of the program for the experimental groups, the same interviewers (with a few exceptions) administered the same questionnaire, in the same room, at the same organization (post-test). Each participant received a token sum of \$10 for each of the measurement periods.

## Variables and measurement tools

Variables were chosen according to the study objectives and design, following similar studies on cognition and the practice of PA in the scientific literature. When French versions of tools were not available, a translation and back translation were carried out to ensure accuracy. Pre-tests of the tools

were conducted during a pilot study with 15 seniors similar to our target population. Detailed information on our tools is reported in a methodological article [77].

### *Sociodemographic characteristics and health*

Sociodemographic characteristics (e.g., age, gender, education, perceived economic resources, living situation) and health characteristics (e.g., health problems, medication and hearing difficulties) were documented using our own questions, as well as questions from pre-existing questionnaires [78]. Researchers assessed participants' perceived economic resources by asking, "How do you see your economic situation compared to other people your age?" Possible answers were: 1) You consider yourself affluent; 2) You consider your income to be sufficient to meet your basic needs and those of your family; 3) You consider yourself poor; 4) You consider yourself very poor. To document participants' perceived health, we asked them to answer the following question: "Compared to other people, which of the following best describes your health?" The response to which could be "excellent," "very good," "good," "fairly good" or "poor". This question was complemented with subjective questions; for example, on memory issues, where participants had to indicate how concerned they were about their memory on a scale of 1 ("not at all concerned") to 10 ("very concerned"). To screen for depressive symptoms, the short version of the Geriatric Depression Scale was used [79]. A question regarding medication was asked to verify the drugs taken among a short list of six categories that could interfere with cognition (are you taking medication for these health problems: epilepsy, sleep difficulties, anxiety/depression, memory problems, high blood pressure, heart problems?). Therefore the number of medications varies from 0 to 6 and does not represent the whole picture. It was nevertheless felt important to control for that in the analysis.

### *Physical activity variables*

PA variables were measured using a questionnaire and an indirect measure of participants' cardiovascular function.

## Practice of physical activity over the past month – CHAMPS

The Community Healthy Activities Model Program for Seniors – CHAMPS [80] was used, as adapted by Robitaille et al. [81]. The original tool is a questionnaire with established validity and reliability (intraclass correlation coefficient of 0.67 and Cronbach's alpha of 0.76) [80]. Our adapted version included 10 items, grouping PA types together and questions allowing researchers to assess the frequency and duration of participation in these activities over the past month (maximum frequency of 28 days of practice per type of activity). Three indicators were created for the analyses: variety of physical activities practiced over the past month, frequency, and volume (total minutes). These indicators matched those used in previous studies [81, 82].

## Indirect measure of cardiovascular function – Senior Fitness Test

The 2-minute step test in the Senior Fitness Test (SFT) [83] is a validated indirect test of participants' cardiovascular function, which has been compared with several other tools (Rockport 1-Mile, Treadmill performance, Rate of Perceived Exertion (RPE)), and has a good test-retest reliability ( $r=0.90$ ,  $n=78$ ) [84]. This tool allows researchers to measure aerobic endurance by determining the number of times the participant can step in place for two minutes. As a precautionary measure, participants completed a Physical Activity Readiness Questionnaire (PAR-Q) [85, 86] before taking the SFT. Despite this measure, a number of eligible participants were unwilling to take the test, possibly because they were afraid or due to the context of the evaluation (noise, fear of becoming tired or short of breath, slight pain).

## Attitudes and behaviours

### Participants' confidence in their memory capacity

Participants' confidence in their memory capacity was measured using the Metamemory in Adulthood (MIA-Capacity) subscale [87]. This tool demonstrated solid metric qualities: a Cronbach's alpha of 0.85 and 0.81 for Hultz et al. [88]; 0.86, 0.82 and 0.86 for Dixon et al. [87]; and 0.77 for our study. The MIA-Capacity is

a subscale consisting of 17 questions, of which 13 were chosen for this study and translated into French. A total score was calculated with a minimum of 13 and a maximum of 65, the highest scores being the best. Participants had to answer statements such as: "I often forget who was with me at events I have attended", on a scale of 1 to 5 (from "strongly agree" to "strongly disagree").

### Feeling of control

To measure participants' feeling of control, we used the Locus of Metamemory in Adulthood (MIA-Locus) questionnaire [87]. The internal consistency of this subscale, using Cronbach's alpha, was 0.84 to 0.89 for Dellefield et al. [89]; 0.79 for Dixon et al. [87]; and 0.64 for our study. The nine questions in the MIA-Locus were translated into French for our study. Question 1 was not used, because it was less correlated with the other items and appeared to be less conceptually relevant. The score varied between 8 and 40. Participants had to respond to statements such as: "I can't expect to be good at remembering zip codes at my age", on a scale of 1 to 5 ("strongly agree" to "strongly disagree").

### Use of memory strategies

To measure participants' use of memory strategies, two validated tools were used: the California Verbal Learning Test II (CVLT-Semantic) [90] and the Multifactorial Memory Questionnaire Strategy (MMQ-Strategy) [91, 92]. The CVLT-Semantic allows verifying whether participants used categorization to remember 16 words during delayed recall. When they used the strategy of sorting names into groups of three or four, they obtained one point per theme, out of a possible four points for four word categories (e.g., furniture, mode of transportation, fruits and animals). We used the MMQ-Strategy to find out how participants had used memory strategies over the previous two weeks in common everyday situations. Participants had to answer questions such as: "How often do you use a timer or alarm to remind you when to do something?" Participants answered on a scale of 0 to 4 ("never" to "always"). A total number of points was calculated with possible values of 0 to 76. We used the French version of the tool, which has

been validated [91, 92]. Our internal consistency for the tool using Cronbach's alpha was 0.57.

### *Cognitive vitality*

Cognitive vitality was measured by documenting cognitive abilities of participants with more formal cognitive testing, as well as cognitive performance in everyday life.

### *Cognitive abilities*

Cognitive abilities were measured with the Montréal Cognitive Assessment (MoCA) [93], the Stroop test [94,95] and the CVLT [96].

The MOCA is a validated tool (Cronbach's alpha of 0.62) consisting of 11 tests evaluating various aspects of cognitive function. This test more specifically aims at screening for, or identifying the presence of, slight cognitive impairment and early-stage dementia. A score lower than 26 out of 30 indicates that the participant may be at risk for cognitive impairments. The Stroop test aims to measure the time taken to carry out a cognitive task with interference, thus allowing to measure selective visual attention. On the two first parts of the test, colours are illustrated (first part) or written (second part) on two different boards. The examinee must name the colour or read what is written as fast as possible, whilst making as few mistakes as possible. The third test consists in naming, as fast as possible and without mistakes, the colour of the ink in which 50 colour words are written (e.g. word "RED" written in green ink). The time required to carry out this third test was chosen as the main indicator of selective attention. The metric qualities of the Stroop test have been demonstrated many times [94, 95].

The CVLT, mentioned above, is a recall test whose metric qualities have also been validated [96]. The CVLT involves asking examinees to remember a list of 16 words belonging to 4 semantic categories. Examinees are allowed five cued-recall trials, in which they have to recall as many of the words as possible (learning score). A second 16-word interference list is then given, and must be recalled. The retention score is the person's ability to remember the 16 words previously heard, compared to the result

obtained on the fifth trial (expressed as a percentage). Strategies used by the examinee to retain the information in the delayed recall phase are also taken into account (e.g., grouping words into categories). This is the semantic score.

### *Cognitive performance in everyday life*

First, the level of attention in everyday life was measured with an adaptation of the Questionnaire d'auto-évaluation de l'attention (QAA) [Self-assessed attention questionnaire] [97]. The authors reported good metric qualities for their tool. In our study, we obtained an internal consistency using Cronbach's alpha of 0.79. The team selected 7 out of the 15 original questions. Participants had to answer statements such as: "When I'm doing an activity, I'm easily distracted by outside noises or the comings and goings around me." This was marked on a scale of 1 to 6 ("never" to "always"). A total score was calculated varying from 7 to 42, the highest results being the best.

Second, everyday memory performances were measured with the Rivermead Behavioural Memory Test (RBMT) [98]. The French and validated version by Vanier and Lemyse [99] was used. This is considered an ecologically valid assessment of memory. The test involves tasks based on everyday life such as remembering names, a story and a route. A score ranging from 0 to 24 was calculated. Participants with the higher scores had the stronger abilities. The metric qualities of the RBMT have been demonstrated. This test is very reliable and its corresponding validity has been reported (correlations ranging from 0.39 to 0.60) with other memory tests [100].

Finally, a self-evaluation of memory performances in everyday life was conducted with the Multifactorial Memory Questionnaire MMQ-Ability test [91], adapted in French by Fort and colleagues [6]. This tool consists of 20 questions such as: "How often do you forget to pay a bill on time?" Participants answered on a scale of 0 to 4 ("never" to "always"). A total score ranging from 0 to 80 was calculated, the highest scores being the best. The tool has solid metric qualities (Cronbach's alpha of 0.93). In our study, the Cronbach's alpha was 0.89.

## Statistical analyses

The collected data was assessed by research assistants and analyzed using the SPSS19® and STATA 10 software. Descriptive analyses were completed as well as bivariate analyses. A threshold of  $p=0.05$  was used for the analyses. To measure the associations between PA and cognition when participants started the study, correlational analyses were used. This was controlled for certain sociodemographic variables (age, gender, years of education), perception of health and memory, and depression. In addition, regression analyses were conducted to measure the effect of the program on three aspects of the practice of PA: volume, frequency and variety. Regression analyses were also used to measure the moderating and mediating effect of PA on the program's impact on cognition.

## Results

### Recruitment

Out of 373 potential participants, 294 met the study's inclusion criteria. Fig. 1 shows the flow of participants through each stage of the study. Attrition during the study brought the number of participants down from 294 to 271 after the second measurement period (post-test). This loss of subjects was greater in the experimental groups (12%) than in the control groups (6%). Reasons given for dropping out of the study included health problems, travel, the difficulty of the program, and a loss of interest. There was no statistically significant difference, in terms of demographic and health measurements, between the participants who continued in the study and those who dropped out.

### Portrait of the sample at baseline

The sample in this study consisted of 294 mostly female older adults. The vast majority of the subjects had a positive view of their health and income, and 62% lived alone. On average, participants had 13 years of education and had worked for 26 years (Table 1).

## Effects of the program on physical activity variables

Table 2 presents the self-reported data gathered on participants' practice of PA in the month prior to the pre-test and post-test—i.e., at baseline and three months later. Walking was the most practiced activity at baseline for all participants, with an average of 13 twelve-minute walks per month. Although it was specified in the question “walk for exercise”, it is possible that some respondents include all types of walking in their responses, inflating this estimate. This was followed by the practice of PA at home (approximately seven times a month) and PA group programs (close to twice a month), lasting an average of 10 and 20 minutes per session respectively.

Table 3 shows participants' data at baseline (pre-test) and three months later (post-test). In both measurement periods, participants, on average, carried out two to three different types of PA. In the experimental group, there was an increase in variety of PA, close to 8%, while there was a 2% decrease in variety in the control group. In terms of frequency, the experimental group showed an increase of roughly 1.5 sessions of PA (6%) per month whilst the control group showed a decrease of close to 3 sessions of PA (11%) per month. With a volume of approximately 300 minutes per week in the pre-test (close to 1200 minutes per month), the experimental group increased its practice of PA following the program (2%) whilst the control group significantly decreased its practice (20%).

The regression analysis revealed significantly different evolutions between the control and experimental groups in terms of the three aspects of PA (Table 4). The variation of averages in the experimental group compared to the control group was significant in terms of variety ( $p=0.02$ ), frequency ( $p=0.01$ ) and number of minutes ( $p=0.01$ ) of PA. Therefore, the Jog Your Mind program had a significant impact on both the number of minutes, the variety and frequency of activities.



**Table 1.** Participant characteristics

	Experimental group (n=143)	Control group (n=151)	Total (n=294)
	Mean (SD) or %	Mean (SD) or %	Mean (SD) or %
Age (years)	71.2 (7.5)	70.7 (7.1)	71.0 (7.3)
Gender (female)	89.5	84.1	86.7
Education (years)	12.2 (3.5)	12.8 (3.8)	12.5 (3.7)
Living alone, %	63.8	59.6	61.6
Marital status (married), %	27.3	28.7	28.0
Perceived socioeconomic status, %			
- Low income/very low income	4.9	8.0	6.5
- Sufficient income	65.5	61.3	63.4
- High income	29.6	30.7	30.1
Perceived health, %			
- Very good, excellent	48.2	48.6	48.4
- Good	32.9	38.7	35.8
- Average, poor	18.9	12.7	15.8
Memory perception (1-10)	6.6 (1.5)	7.0 (1.5)	6.8 (1.5)
Memory concerns (1-10)	5.9 (2.5)	5.3 (2.8)	5.6 (2.7)
MoCA score	25.7 (3.4)	25.6 (3.3)	25.7 (3.4)
Depression, %	24.5	15.9	20.1
Number of medications* (0-6)	.91 (.87)	.91 (.95)	.91 (.91)
Volume of physical activity (min. per month)	1157.8 (1018.2)	1230.6 (1082.8)	1194 (1050.5)
Frequency of physical activity (times per month)	29.9 (19.6)	29.8 (20.6)	29.8 (20.0)
Number of different physical activities (over a month)	2.7 (1.4)	2.5 (1.4)	2.6 (1.4)

\* Number of medications taking in a list of 6 categories that could interfere with cognition

Moderating and mediating effects of PA on the program's impact on cognition

Beyond the initial effects of the program on cognitive vitality, a regression calculation adjusted for sociodemographic and health variables was made in order to assess whether PA had a moderating effect on the program's impact on cognition. If this was the case, the program would presumably be influenced by participants' level of PA at study entry. The analysis of the experimental group data (analysis not illustrated) showed that the evolution of cognitive

functions following the program was not significantly different among those who were physically active at baseline and those who were not.

A possible mediating effect was also verified, i.e., whether the effect of the program on cognitive vitality was significantly influenced by the variation in participants' level of PA during the study. The analysis did not reveal any significant results ( $p < 0.05$ ) (analysis not illustrated). A change in cognitive test results was therefore not necessarily mediated by an increase in the practice of PA during the program.

**Table 2.** Participants' physical activity over the past month in frequency and minutes

Type of PA	Measurement	Experimental group		Control group	
		Pre-intervention (n=143)	Post-intervention (n=128)	Pre-intervention (n=151)	Post-intervention (n=143)
		Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
Walking*	Frequency/month	12.94 (11.05)	11.04 (10.20)	13.95 (11.96)	12.01 (11.70)
	Duration/session (min.)	36.54 (30.81)	33.53 (26.61)	35.44 (38.14)	35.83 (40.01)
Home PA program	Frequency/month	8.31 (11.65)	9.88 (11.96)	5.66 (10.24)	5.66 (9.97)
	Duration/session (min.)	9.03 (14.50)	9.84 (13.48)	6.72 (13.27)	5.39 (9.51)
Gardening	Frequency/month	2.21 (6.41)	1.10 (4.02)	2.11 (6.41)	.42 (2.59)
	Duration/session (min.)	11.48 (39.28)	12.30 (37.81)	15.32 (49.40)	6.85 (27.07)
Group PA program	Frequency/month	2.02 (4.53)	2.15 (3.40)	1.37 (3.65)	1.88 (4.52)
	Duration/session (min.)	18.95 (34.15)	27.24 (38.96)	17.95 (32.87)	20.00 (34.52)
Cycling	Frequency/month	1.40 (4.53)	1.68 (5.16)	.96 (4.11)	.46 (2.12)
	Duration/session (min.)	4.92 (16.90)	4.92 (15.91)	5.07 (21.19)	1.71 (7.05)
Dance	Frequency/month	.93 (2.56)	1.05 (2.60)	.60 (1.32)	.94 (3.22)
	Duration/session (min.)	12.22 (28.80)	23.59 (61.47)	13.22 (34.41)	15.03 (35.43)
Aquafit/ swimming	Frequency/month	.92 (3.55)	.72 (2.35)	.92 (2.38)	.71 (1.97)
	Duration/session (min.)	6.19 (17.03)	6.25 (17.84)	10.66 (23.73)	10.28 (23.12)
Golf, tennis, bowling, skating	Frequency/month	.33 (1.35)	.30 (1.49)	.27 (1.43)	.22 (.95)
	Duration/session (min.)	12.56 (45.52)	11.33 (43.13)	9.87 (34.38)	9.25 (33.82)

\* It is possible that some respondents includes all types of walking in their responses

**Table 3.** Outcome variables at baseline and post-intervention, and program effect size

Physical Activity Variables	n	Baseline	Post-intervention	Effect size	% of change
		Mean (SD)	Mean (SD)	-	%
Number of different physical activities (over a month)	270	2.6 (1.4)	2.7 (1.5)		
Experimental	128	2.7 (1.4)	2.9 (1.3)	.150	7.692
Control	142	2.5 (1.4)	2.5 (1.5)	-.028	-1.606
Frequency of physical activity (times per month)	268	29.4 (19.6)	28.6 (20.0)		
Experimental	126	30.1 (19.2)	31.7 (20.1)	.095	6.074
Control	142	28.8 (20.0)	25.6 (19.5)	-.028	-10.976
Amount of physical activity (min. per month)	264	1173.5 (1018.9)	1062.6 (946.9)		
Experimental	126	1134.7 (945.9)	1160.3 (969.0)	.027	2.253
Control	138	1208.9 (1083.5)	973.4 (920.7)	-.217	-19.478

**Table 4.** Regressions adjusted by group for pre-/post-test PA practice data

Variables Measured	Regressions*			
	Raw $\beta$	$\beta$	P	R <sup>2</sup>
PA minutes (n=262)	253.01	.13	.01	.34
PA frequency (n=266)	6.11	.15	.01	.30
PA variety (n=268)	.36	.12	.02	.34

\* Model adjusted for: age, gender, perceived health, years of education, depression, MoCA, perceived memory, living situation, perceived socioeconomic situation and medication

### Associations between level of physical activity and cognitive vitality at baseline

In a cross-sectional analysis of the pre-test data, correlations were made to study possible associations between the practice of PA and cognition (Table 5). These correlations were adjusted for 10 sociodemographic and health variables. Only recourse to memory strategies (MMQ Strategy) was significantly correlated with the number of minutes ( $p=0.047$ ), frequency ( $p=0.001$ ) and variety ( $p=0.017$ ) of PA over the past month.

**Table 5.** Adjusted correlations between the levels of PA and cognition at baseline \*

Variables	Feeling of confidence	Feeling of control	Attention level	Memory strategies		Cognitive skill			Cognitive performance	
	MIA Capacity	MIA Locus	QAA	CVLT (Semantic)	MMQ Strategy	Stroop	CVLT (Learning)	CVLT (Retention)	RBMT	MMQ Ability
PA: volume (per month)										
Correlation	.066	-.084	-.103	-.065	.119	-.022	.032	.023	.002	.008
Significance	.269	.163	.084	.283	.047	.717	.596	.711	.979	.892
Degree of freedom	278	278	278	269	278	275	270	269	278	278
PA: frequency (per month)										
Correlation	.098	.059	-.051	.001	.206	-.027	.035	.067	-.014	.053
Significance	.102	.327	.401	.989	.001	.658	.566	.272	.812	.382
Degree of freedom	276	276	276	267	276	273	268	267	276	276
PA: variety (per month)										
Correlation	.025	-.033	-.083	-.009	.142	-.005	.066	.037	-.022	.000
Significance	.676	.582	.167	.879	.017	.930	.275	.549	.720	.995
Degree of freedom	278	278	278	269	278	275	270	269	278	278

\* Adjusted for: age, gender, perceived health, years of education, depression, MoCA, perceived memory, living situation, perceived socioeconomic situation and medication

## Discussion

This quasi-experimental study aimed to explore: 1) the effect of the Jog Your Mind program on the practice of PA; 2) the moderating and mediating effect of PA on the program's impact on cognition; 3) the association between PA and various aspects of cognition before participants started the cognitive vitality program. In total, 294 individuals aged 60 and over were assessed using cognitive tests and questionnaires, as well as tools to measure PA. Based on the correlations at baseline, and multiple pre- and post-test regressions to measure the impact of both the program and the practice of PA, it was found that participation in the program was associated with an increase in PA; however, the practice of PA did not have a significant moderating or mediating effect on cognition. Finally, in the total sample the most active subjects, prior to entering the study, used more memory techniques as measured with a self-administered questionnaire.

### Jog your mind to jog your heart!

The main objective of this study was to explore the impact of participation in the Jog Your Mind program on the practice of PA in a sample of 294 elderly participants who did not have a diagnosis of cognitive impairment. Our hypothesis of a positive impact was confirmed, since the members of the experimental group significantly increased or maintained their volume, frequency and variety of PA following the program when compared to the control group, in which all members significantly decreased their practice.

A number of researchers have shown that the use of promotional strategies in group sessions (e.g., walking groups) can lead to an increase in older adults' practice of PA [25, 101-104]. However, this effect has not, to our knowledge, been studied in the context of multifactorial cognitive vitality programs. It is also worth noting that, in this type of program, there is a risk that the variety of objectives involved could reduce the intensity and specificity of the interventions. Nonetheless, the Jog Your Mind experience showed that it is possible to bring about significant changes in lifestyle habits through a multifactorial program, offered in a community

context by individuals without a specific expertise. The results are even more encouraging given that these changes in lifestyle habits not only have a potentially positive impact on participants' cognitive vitality, but also on their health and well-being.

It would have been interesting to know more about subjects' motivations for taking part in the study. Table 1 shows that, at study entry, many of the participants were slightly concerned about their cognitive performance. These concerns might have motivated participants in the experimental group to change their practice of PA. Since loss of cognitive functions is a frequent concern for the elderly [105, 106], there is a strong argument for including the maintenance of cognitive vitality in future campaigns to promote PA in this population.

### Did PA really jog the mind of study participants?

Our second objective was to examine the moderating or mediating effect of PA on the cognitive vitality of seniors participating in the program. Contrary to what the literature had led us to anticipate [11, 65, 66, 68-70], neither of these two effects were observed. As far as the moderating effect was concerned, participants with a higher level of PA (in terms of volume, frequency and variety) gained no greater benefit from the intervention in cognitive terms than those who were less active at the start of the program. The short period for the CHAMPS measurement (one month) could also have led to an exaggeration or minimization of certain individuals' PA practice at the start of the study, and did not reflect their cumulative practice in recent years, or over the course of their life. Our results are similar to those of Sawatzky [70], who has also worked with this type of self-reported data to measure the impact of PA on the health of older adults. Sawatzky also makes similar observations on the disadvantages of using this type of data for measuring moderating or mediating effects.

As far as the mediating effect of PA was concerned, our analyses suggested that an eventual improvement in the cognitive function of participants did not necessarily depend on an increase in their practice. In this regard, studies have revealed multiple factors that could influence the cognitive performance of seniors, ranging from intrinsic (e.g., health, age), to



behavioural (e.g., involvement in stimulating activities), or environmental (e.g., living environment) [107-109]. The relative importance of each of these factors and their mutual influence are not clearly known, but studies tend to look at the impact of these factors after long-term exposure (a number of years, or even a lifetime)[64, 67, 69, 110, 111]. It is therefore not surprising to note that, considered in isolation in this multifactorial study, changes in the practice of PA were not sufficient to explain the evolution of participants' performance on cognitive tests during the program. It is also possible that certain types of intervention have more rapid functional results, depending on the cognitive domains involved. For example, when participants are taught memory strategies, they could directly apply them in cognitive tests or assessments. The effects of these strategies could therefore be measurable in the very short term [49, 112-114]. However, as presented in the introduction to this article, the neurophysiological changes tied to an improvement in lifestyle habits such as the practice of PA are complex, and their functional benefits could take longer to become apparent [115-118]. In this regard, it will be interesting to see the results of the third measurement period (one year after study entry).

### **The association between PA and cognitive vitality: results of cross-sectional analysis**

The third objective of this study involved conducting a cross-sectional analysis to assess the relationship between the practice of PA and the cognitive vitality of older adults. At study entry, only the use of memory strategies (MMQ-S) was significantly correlated with PA variables. Thus, participants who had engaged in more PA over the previous month used more memory strategies. Perhaps this association shows participants' general proactive attitude with regard to aging, reflected both in their practice of PA and in the strategies they used to maintain their cognitive performance in everyday life. It would have been interesting to see whether such a relationship also existed with other lifestyle habits such as healthy eating.

However, the fact that no association was found contradicts the results of several other cross-sectional studies showing that higher-fit individuals had better

scores on a number of cognitive tests, including processing speed [119] and attention [120]. That being said, at study entry, participants' average practice of PA was 1195 minutes per month (close to 300 minutes per week), which potentially meets the recommendations of the main PA guidelines [9, 16, 17]. It is important to note that these recommendations are related to the practice of moderate-intensity PA, and the intensity of participants' PA in this study was not measured. It is therefore likely that a sizeable proportion of the study participants did not really respect the recommendations. If we take this factor into account and include the possibility that participants engaged in low-intensity activities, this could explain the lack of a significant correlation between the PA practice level and most of the cognitive variables at study entry. It is also possible that our elderly subjects reported higher PA levels than was actually the case in order to please the study interviewers.

Since PA inevitably involves certain cognitive tasks and a degree of social interaction (from none to high), the positive effects of PA on cognition may be influenced by the type of activity practiced [40]. Given that physical activities were not categorized in terms of their physical, social and cognitive aspects, it is likely that seniors with a low frequency of more complex activities reduced the practice average, but might have derived superior benefits (e.g., greater attention) in the cognitive tests than those practicing a simple activity such as walking alone, with higher frequency and volume scores. Further studies are needed to analyze the effects of PA on the cognitive vitality of seniors according to the activity types proposed, for example, by Karp et al [40]. The same applies to the intensity of the practice, which was not included in the questionnaire administered to the participants in our study, but which could also influence associations between the PA practice level and cognition.

It is also important to bear in mind that certain cross-sectional studies have not demonstrated significant effects of PA on cognition [28]. It is possible that the data-gathering tools used (e.g., direct measurements versus self-reported questionnaires), the data-gathering period (e.g., long-term practice versus practice over the past month), the aspect of the PA under study (e.g., volume versus intensity) and the

cognitive functions assessed (e.g., memory versus executive functions) might explain the contradictory results observed in the literature.

### Strengths and limitations

A quasi-experimental design was chosen to study the effects of the Jog Your Mind program in real life. The subjects in the control group were followed the program one year later than the experimental group, but the inclusion criteria were the same for both groups. The research team provided a subject pre-selection chart to all of the community organizations to assist them in the recruitment process. The research coordinator then validated the participants' eligibility. A number of variables were documented to verify the comparability of the groups at the start and to make subsequent adjustments, using rigorous analyses.

An ecological approach was used to evaluate program outcomes, and the tests took place in the participating community organizations (as opposed to laboratories or research centres). The interviewers had received training to ensure uniformity in the data-gathering process. They were closely followed and several adjustments were made, especially at the beginning. Assessments were completed in the same room each time and carried out by the same interviewers (with a few exceptions). No intrinsic measurements were taken to measure variations in cognitive function and health (e.g., brain scans). Our indirect data therefore had a small, but acceptable margin of error. Although we did not use intrinsic measurements, we selected standardized assessment tools in the literature that allow this study to be compared with future studies and to be included in meta-analyses and literature reviews. PA practice was estimated based on an adapted version of the CHAMPS questionnaire—a validated tool allowing us to assess the volume (minutes), frequency and variety of physical activities practiced by participants. In our initial study methodology, we planned to use an indirect measurement of participants'  $\text{VO}_2$  max. However, this measurement could not be included due to inconsistencies in the data-gathering process at the community organizations (the 2-minute step tests). This indirect measurement of participants' cardiovascular capacity might have allowed us to reach different conclusions in terms of the correlations

between the practice of PA and cognitive vitality at the start of the study.

This study was carried out directly in the community organizations that will use the program with our target clientele. Our results can therefore be applied to future participants who are concerned about their memory, but who have not received a diagnosis of cognitive impairment.

### Conclusions

The study showed that it is possible to get older adults to adopt a more active lifestyle through a program aimed at promoting cognitive vitality. The data from the follow-up assessment nine months after the end of the program will allow us to conduct further analyses and verify if the benefits were sustained. Further studies should be conducted to analyze the impact of promoting the practice of PA on the acquisition of healthy lifestyle habits and to evaluate the effects of this voluntary practice on program participants' cognitive vitality. Further studies are also needed to explore the associations between the various aspects of PA (volume, frequency, intensity, type, complexity, variety) and cognitive vitality. It will be important, in these studies, to use a maximum number of validated measurement tools for both the different aspects of cognition and PA.

### Acknowledgements

The authors would like to thank all of the community organizations and seniors in Greater Montreal who participated in this study, as well as the entire research team.

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