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ORIGINAL

EFFECTS OF BRAIN GYM® EXERCISES ON INSTITUTIONALIZED OLDER ADULTS WITH COGNITIVE IMPAIRMENT

APLICACIÓN DE EJERCICIOS DE BRAIN GYM® EN PERSONAS INSTITUCIONALIZADAS CON DETERIORO COGNITIVO

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ABSTRACT

This study aimed at comparing the effects of a program based on Brain Gym® exercises against a fitness exercise program on the cognitive function and functional independence in institutionalized older adults with cognitive impairment. Twenty-nine institutionalized older adults with cognitive impairment took part either on a Brain Gym® exercise-based program or on a fitness exercise program for eighteen weeks. The assessment measures used were: Mini-Examen Cognoscitivo, Fototest, Trail Making Test, Barthel Index and the Timed Up and Go Test. None of the variables analyzed improved significantly. A trend towards improvement, particularly in the fitness exercise group, in both cognitive status and functional independence was observed. In conclusion, the performance of a Brain Gym® exercise-based program had the same effects as taking part in a fitness exercise program, with no significant improvements on the cognitive function or functional independence in a sample of institutionalized older adults with cognitive impairment.

KEY WORDS: Human physical conditioning; Physical activity; Frail elderly; Institutionalization; Cognition disorders.

RESUMEN

Este estudio tuvo como objetivo comparar los efectos de un programa de ejercicios de Brain Gym® con un programa de gimnasia de mantenimiento en pacientes mayores institucionalizados con deterioro cognitivo. Veintinueve personas institucionalizadas con deterioro cognitivo participaron en dos programas, uno basado en ejercicios de Brain Gym® y otro de gimnasia de mantenimiento, durante 18 semanas. Se emplearon los test Mini-examen cognoscitivo, Fototest, Trail Making Test, Índice de Barthel y el Timed up and Go. No se encontraron mejoras significativas en las variables analizadas. Se observó una tendencia positiva, especialmente en el grupo de gimnasia de mantenimiento, en la función cognitiva global y salud física. En conclusión, los efectos de un programa de ejercicios de Brain Gym® en una muestra de personas mayores institucionalizadas con deterioro cognitivo fueron similares a los de un programa de gimnasia de mantenimiento, sin mejoras significativas de la función cognitiva o independencia funcional.

PALABRAS CLAVE: Ejercicio físico; Gimnasia cerebral; Deterioro cognitivo; Condición física; Adulto Mayor; Institucionalizados.

INTRODUCTION

Current scientific evidence has confirmed that physical exercise performance is a very useful strategy in older adults. For instance, it has been observed that their level of independence and mental health are positively affected if they lead an active lifestyle[1]. In this regard, it has been contrasted that the performance of physical activity in older adults not only has beneficial effects on their physical condition and quality of life, but also on their cognitive functions[2], such as slowing down the process of cognitive deterioration, increasing processing speed and ameliorating both the executive function and delayed recall[3].

In this connection, most of the research attention has been placed on the physical activity modalities which focus on fitness exercise and muscular strength programs[4]. Apart from said programs, which may be referred to as traditional, other types of activities have recently emerged, which, in combination with physical movement, are particularly oriented towards cognitive training, as would be the case of Brain Gym® (BG)[5].

Originally developed for children with learning difficulties, this modality of structured physical exercise is based on the combination of specific movement patterns which involve the head, eyes and limbs, as well as cognitive and breathing exercises. According to their creators, regular performance of the BG program results in the stimulation and integration of different parts of the brain, especially the corpus callosum, and this contributes in the long run to improving the speed at which both brain hemispheres communicate with each other and to integrating higher order thinking skills[6].

The results obtained from studies which considered the efficacy of BG programs are rather contradictory. On the one hand, Sidiarto et al.[7] carried out an experiment with a cognitively healthy, non-institutionalized sample of older adults whose conclusions pointed to improvements in recall, sustained attention and visual search skills after the application of a program –with a duration of two months and two sessions per week– featuring similar movements following a musical track. In any case, it should be mentioned that the data analysis provided in the paper is limited by a design which lacked a control group. Using a comparable approach, Yágüez et al.[8] performed a small randomized controlled trial which recorded an improvement in the cognitive function of institutionalized older adults with dementia after the application of a weekly BG program. However, none of these studies contrasted the results derived from a BG exercise-based program intervention with those of other types of physical activity therapies. In this regard, Cancela et al.[9] did not find the application of a BG program, performed once a week in one-hour sessions, to have a significant impact on the cognitive function of healthy older adults, or that the effects of the program were superior to those of a traditional fitness exercise intervention. The absence of randomization in this last study somehow limits the strength of its findings and the methodological quality of the experimental design.

Consequently, it may be stated that the scientific evidence currently available concerning the benefits of BG program performance on the cognitive and physical condition variables of older adult populations is still scarce, mainly in the case of institutionalized populations, which calls for the design and implementation of further experimental studies.

OBJECTIVE

The objective of the present research study was to identify the effects on cognitive function and functional independence of a BG exercise-based program and contrast the results with a traditional fitness exercise program in a group of institutionalized older adults with cognitive impairment.

MATERIALS AND METHODS

PATIENTS

The sample was composed of 29 patients, recruited in a geriatric facility in the north of Galicia (Spain). The inclusion criteria were as follows: (1) cognitive deterioration (Mini-Examen Cognoscitivo [MEC] < 24)[10]; (2) no severe mobility problems; (3) no aggressive behavior; and (4) capacity to follow a set of guidelines and to perform physical exercises during the sessions. In contrast, a health condition that could likely prevent physical assessment or exercise performance was considered an exclusion criterion. The only activities offered by the care center, outside those which were already part of the intervention, consisted in handicraft work. The participants who volunteered for the study did not attend said activities during the intervention. Table 1 shows the main characteristics of the sample before the experiment began.

Table 1. Sample characterization data before the intervention took place

	Group 1: Brain Gym® (n = 15)	**Group 2: Fitness exercise (n = 14)**	
	Mean ± Standard deviation	Mean ± Standard deviation	Student's *t* (Homogeneity)
Age (years)	80.87 ± 8.42	82.07 ± 9.38	t = -0.364; p = 0.718
Mini-Examen Cognoscitivo	17.93 ± 6.10	17.43 ± 4.38	t = 0.254; p = 0.801
Fototest	23.20 ± 10.21	26.07 ± 8.71	t = -0.812; p = 0.424
Trail Making Test: Part A (s)	190.75 ± 133.99	199.90 ± 69.41	t = -0.195; p = 0.848
Barthel Index	52.00 ± 33.37	53.57 ± 25.83	t = -0.141; p = 0.889
Timed Up and Go Test (s)	21.74 ± 10.62	17.40 ± 9.30	t = -1.025; p = 0.317

The board of directors of the geriatric facility, as well as the managers of its foundation, gave their consent after being duly informed of the experimental procedure. Assistance was requested from a physician, a social worker and a psychologist, who were employed by the geriatric facility but had no connection with the present study. The sample of patients were also informed about the procedure and agreed to take part following the medical approval whereby their health would not be at risk at any point in the entire program. This study was performed in accordance with the Declaration of Helsinki[11] and abiding by the European Guidelines on Good Clinical (Research) Practice (111/3976/88; 1st

July 1991), as well as the existing Spanish legal framework concerning clinical research with human subjects (Royal Decree 561/1993, on clinical trials).

INTERVENTION

A randomized controlled trial was designed (EudraCT Code: 2017-000510-30) and participants were divided into two different groups. One of the groups followed a BG exercise-based program, while the other performed a more traditional Fitness Exercise (FE) program. Participant assignment to each group responded to an Excel® simple random selection.

The intervention lasted 18 weeks –two sessions of 30 minutes per week–for both groups. The exercises performed by participants in the BG group were 19 of those described in Dennison and Dennison[5], although “Cross Crawl” was adapted to the participants’ capacity to stand on their own. The exercises performed by participants in the FE group were adapted to their functionality in such a way that each session comprised three separate phases: activation, main part and cool down. Table 2 describes the typology of one of the sessions for each group. Both physical exercise programs were administered and supervised from start to finish by a graduate in Physical Activity Sciences and Sports.

Table 2. Session typology for each program

BRAIN GYM®	FITNESS EXERCISE PROGRAM
	Activation phase (10 minutes)
· *Belly breathing (1 min).* · *Cross crawl (2 min).* · *Lazy eights (2 min).* · *The elephant (2 min).* · *Hook ups (2 min).* · *Neck rolls (1 min eyes open / 1 min eyes closed).* · *The owl (2 min).* · *Arm activation (1 min per arm).* · *The elephant (2 min).* · *Foot flex (1 min per foot).* · *Cross crawl (2 min).* · *Gravity glider (1 min).* · *Brain buttons (1 min).* · *Earth buttons (1 min).* · *Cross crawl (2 min).* · *Balance buttons (1 min).* · *Space buttons (1 min).* · *Energy yawn (1 min).* · *The energizer (1 min).*	*Articular mobility:* · *Wrists* · *Fingers* · *Elbows* · *Shoulders* · *Ankles* · *Knees* · *Hips* · *Neck*
	Main part (15 minutes)
	With a foam ball: · *Move forwards and backwards from the chest.* · *Press with both hands at chest height.* · *Turn around the waist.* · *Move forwards, sideways, upwards and again sideways.* · *Go up and down with one hand.* · *Draw circles on the floor.* · *Pass from one hand to the other.* · *Press with both knees.* *With a pair of sticks:* · *Roll up and down from thigh to foot.* · *Move forwards and to the chest, upwards and back to the chest.* · *Row on the right side, then on the left.* · *Draw circles on the floor.* *With balloons:* · *Throw and catch, in pairs.* · *Throw and catch, in a circle. More balloons added.* *With chairs:* · *Roll feet from toe to heel.* · *Move hips sideways.* · *Kick knees up, then heel to buttocks.* *With small rubber balls:* · *Press with hands, then fingers.* · *Stretch arm forwards and press with hands.* · *Turn as if rubber balls were door knobs.* *Standing:* *March laterally moving around hoops and climbing step up and down.*
	Cool down (5 minutes)
	Mimicry: Wrinkle nose, open and close eyes, smile, puff cheeks, lick lips. *Breathing exercises: Inhale through the nose and raise arms; exhale as arms gradually descend.*

ASSESSMENTS

COGNITIVE FUNCTION: To identify the effects of the intervention on the participants' cognitive function, three tests were employed.

The first of the tests was the MEC, which was used to detect cognitive impairment and monitor its evolution in patients with neurological alterations, especially older adults, with the main aim of assessing spatio-temporal orientation, attention span, focus and recall, mental calculation and language skills, visual-spatial perception and the ability to follow basic instructions. The score ranges from a maximum of 30 to a minimum of 0 points. A score of 30 points indicates a healthy cognitive state.

The second of the tests was the Fototest[12], which was used to assess the effects the intervention had on the participants' memory through free recall and cued recall of images, executive function (verbal fluency) and denomination (language). This test is particularly indicated to detect signs of cognitive impairment and dementia. There is no maximum score: the higher the score, the better the cognitive state.

The third test was the Trail Making Test (TMT)[13], whose nature is neuropsychological and is used to detect cognitive impairments such as Alzheimer and dementia. Considering the number of years of formal education that the participant has received, it evaluates visual search speed, scanning, processing speed and mental flexibility. It consists of two parts in which the participant is asked to join 25 points with a straight line as quickly and accurately as possible. The points in part A, within the 1–25 range, are randomly distributed and the participant joins them in increasing order. In part B, numbers and letters are joined sequentially (1–A, 2–B, etc.). The participant's main objective is to finish both parts as quickly as possible. Given the difficulty the sample of participants found to complete part B, only part A was administered.

FUNCTIONAL INDEPENDENCE: To determine whether the effects of the program were dependent on the participants' functional autonomy, the Barthel Index (BI)[14] was employed. A total of 10 activities of daily living (ADL) are assessed on a scale from 0 to 100, where 100 is the maximum score. Then, participants were classified into the following categories according to the number of points they had obtained: independence (100 points; or, 95 points if the person is on a wheelchair), mild dependence (>60 points), moderate dependence (55–40 points), great dependence (35–20 points) and complete dependence (<20 points).

Additionally, the Timed Up and Go Test (TUG)[15] was used to assess basic functional mobility and locomotive capacity (dynamic balance) in older adults. The test consists in standing up from a chair, walking a 3-meter distance, going back and sitting again. A stopwatch is used to register the time the participant takes to complete the process. This test is considered useful in clinical trials given its simplicity and ease of administration.

The assessments were completed one week before the intervention started and one week after it finished. The cognitive function and functional independence tests were administered by the in-house psychologist and physiotherapist respectively. Neither specialist knew the intervention group to which the participants belonged.

STATISTICAL ANALYSIS

The descriptive analysis of the sample was carried out through central tendency measures (mean and standard deviation). The Kolmogorov-Smirnov test ($p > 0.05$) was used to check sample normality. Student's *t* test for independent data was employed as a measure of homogeneity of the variables under analysis.

The analysis of the effects each program had on the corresponding group was performed through Student's *t* test for paired data samples. With the aim of determining the differential effect of each program on the sample, a variance analysis (ANOVA; 2 x 2) was carried out. IBM SPSS v. 21 was used for the statistical analysis, considering $p < 0.05$ as the level of significance.

RESULTS

The sample was distributed as follows: 15 participants were assigned to the BG group (mean age: 80.87 ± 8.42; 46.6% women) and 14 to the FE group (mean age: 82.07 ± 9.38; 71.4% women). One participant died during the study; therefore, the final sample was made up of 28 patients. The statistical analysis indicated that the two groups were comparable, since no significant differences were observed when the program started. Table 3 shows the results of the initial and final assessment for the BG group and the FE group.

Table 3. Assessment results for both groups, before and after the intervention

	Group 1: Brain Gym® (n = 15)			**Group 2: Fitness exercise (n = 14)**			
	Pre	Post		Pre	Post		
	Mean ± SD	Mean ± SD	Student's *t*	Mean ± SD	Mean ± SD	Student's *t*	ANOVA M x P
Age (years)	80.87 ± 8.42	80.87 ± 8.42	-	82.07 ± 9.38	82.07 ± 9.38	-	-
Mini-Examen Cognoscitivo	17.93 ± 6.10	17.87 ± 4.94	$t = 0.033$ $p = 0.974$	17.43 ± 4.38	17.21 ± 3.26	$t = 0.147$ $p = 0.884$	$F_{1.47} = 0.003$ $p = 0.973$
Fototest	23.20 ± 10.21	23.73 ± 12.09	$t = -0.131$ $p = 0.897$	26.07 ± 8.71	26.86 ± 7.87	$t = -0.250$ $p = 0.804$	$F_{1.47} = 0.002$ $p = 0.962$
Trail Making Test: Part A (s)	190.75 ± 133.99	157.00 ± 96.51	$t = 0.665$ $p = 0.514$	199.90 ± 69.41	138.29 ± 56.48	$t = 1.937$ $p = 0.072$	$F_{1.47} = 0.185$ $p = 0.669$
Barthel Index	52.00 ± 33.37	55.67 ± 32.06	$t = -0.307$ $p = 0.761$	53.57 ± 25.83	62.14 ± 21.64	$t = -0.952$ $p = 0.350$	$F_{1.47} = 0.105$ $p = 0.747$
Timed Up and Go Test (s)	21.74 ± 10.62	23.32 ± 11.97	$t = 1.095$ $p = 0.291$	17.40 ± 9.30	13.06 ± 5.62	$t = -0.335$ $p = 0.741$	$F_{1.47} = 0.832$ $p = 0.368$

SD: Standard deviation; M x P: Moment times Program; Pre: Pre-intervention; Post: Post-intervention.

The data analysis reveals that no significant effects on the selected variables were found for any program. In any case, after comparing the results of the initial and final assessment, a tendency towards improvement was detected in all participants, which was more marked in the FE group. Therefore, while the assessment of cognitive impairment through MEC indicated that it had remained stable during the intervention, improvements were attested in the capacity for recall, visual speed and scanning, information processing, as well as basic functional mobility, locomotive capacity and functional independence.

DISCUSSION

The present research intended to analyze the effects of a Brain Gym® exercise-based program on institutionalized older adults with cognitive impairment and contrast them with those of a traditional fitness exercise program. The results obtained indicate that none of the programs had a significant effect on the participants' cognitive function or their level of dependence. These findings are contrary to some of those published to date.

Firstly, Yágüez et al.[8] found a significant improvement after applying a Brain Gym® exercise-based program of 2 hours per week for 6 weeks, in terms of attention focus, visual recall and working memory in Alzheimer patients. Along the same lines, Sangundo[16], after applying a BG program 5 times per week for 3 weeks to a sample of 30 older adults, concluded that a significant effect had been attested as far as cognitive function was concerned, given the score increases in the Mini-Mental State Examination.

One of the main reasons that could explain these differences would be the duration of the present study and of the sessions in which it was structured (approximately 30 minutes). Such low frequency in a relatively short intervention might not have been sufficient to improve the cognitive performance of the sample. However, the other studies mentioned above combined higher frequencies with even shorter interventions, which does not contribute to clarifying the diversity of results. Perhaps a higher number of sessions per week, rather than a longer time span could result in a greater and more effective stimulus to produce significant changes in the variables under study.

In addition, the absence of efficacy in the program applied to patients in the present study might have been due to their cognitive state. In this regard, Sidiarto et al.[7] achieved significant improvements in the visual search and language skills, as well as on attention focus and short-term memory in a sample of older adults without cognitive impairment after the application of a cognitive stimulation program similar to BG. However, judging by the scores obtained in the cognitive function tests, the sample of participants selected for this study presented what may be judged as moderate cognitive impairment. It could perhaps be the case that the efficacy of BG in populations with cognitive impairment is contingent upon a training threshold under which the effects of its application do not acquire special relevance.

Another remarkable finding lies in the fact that the BG exercise-based program did not prove to have significantly superior effects to the traditional fitness exercise programs on the variables under analysis. These results are in line with the observations of other researchers, although such studies refer to healthy populations. In this regard, Forte et al.[17] found that a program based on cognitive tasks and another program based on traditional physical activity produced the same effects on a selection of cognitive variables in healthy older adults. Similarly, Cancela et al.[9] did not find significant differences between the effects of a BG and a traditional exercise program in terms of cognitive function and physical condition. Likewise, Kuster et al.[18] did not find significant differences at the cognitive level after contrasting a BG program with a traditional physical activity program in older adults with memory problems.

In any case, the present study compared the evolution of two groups and observed a tendency towards improvement that was significantly higher in the case of the traditional fitness exercise program. This might be due to the characteristics and typology of the sessions participants performed, which relied on aerobic exercise and muscular strength.

There is extensive research on the effects of different physical exercise programs in older adult populations, as those mentioned in the revision published by Bherer et al.[3], in which relationships are drawn between direct measures of cardiorespiratory fitness, such as VO_2 max, and cognition in early Alzheimer patients. Even though the exact mechanism by which cardiorespiratory fitness and Alzheimer are interrelated is still unknown, in mice with Alzheimer it has been found that an association exists between increases in physical activity and reductions in the neuropathological load in the cortical-hippocampal regions, which would suggest that exercise might act as a mediator in the amyloid cascade, thus favoring a reduction in beta-amyloid production[19]. Aerobic exercise, in addition to incrementing the volume of blood in the brain[20], as well as perfusion in the hippocampal region[21], causes the anterior portion of this region of the brain to increase in size, as Erickson et al.[22] reported, which is precisely where the neurons have been associated with visuospatial memory[23], yielding improvements in this component of the cognitive function[24]. Erickson et al.[22] also demonstrated that an increase in the volume of the hippocampus translates into higher serum levels of Brain-Derived Neurotrophic Factor (BDNF), which acts as a mediator in dentate gyrus neurogenesis.

Regarding strength training and improvements in the cognitive function, Cassilhas et al.[25] found that moderate-to-high intensity strength training delivered benefits which were similar to those of aerobic exercise programs in older adults. After attesting a surge in the circulating levels of IGF-1 immediately after the strength-intensive exercise, they found statistically significant correlations between the levels of that protein and the cognitive function. The authors believe that this mechanism may be due to its transport to the nervous system through the blood-brain barrier, thus ameliorating cognition by means of various mechanisms. In this sense, Trejo et al.[26] concluded that circulating levels of IGF-1 acted as a mediator to increase the number of new neurons in the hippocampus, which might be induced by physical activity.

An analysis of the results at the level of functional independence showed that the tendency to improvement was more remarkable in the FE group rather than the BG group. In the case of TUG, following Sai et al.[27], this test offers the best measure of balance to predict recurrent falls. Numerous studies confirm that aerobic exercise programs, if the cardiovascular system and muscular strength are involved, lead to improvements in the subject's level of physical condition. This level is directly and significantly related to functional independence –and, in consequence, quality of life and the prevention of falls–, as shown in the revision and meta-analysis by Chase et al.[28]. In contrast, the BG exercise-based program does not focus on such physical parameters; therefore, the stimulus might have been less intense than that of the FE program.

In this respect, it should also be mentioned that in spite of not leading to significant improvements, the intervention might have slowed down the process of involution that institutionalized older adults with mild cognitive impairment experience both in their cognitive function[29,30] and in their level of autonomy and functional independence[31]. However, the lack of a monitoring phase in the research design, together with the absence of a control group which did not exercise, makes it difficult to substantiate this hypothesis. These aspects, added to the small size of the sample, constitute the principal methodological limitations of this study and therefore they should be taken into consideration at the time of interpreting the results offered herein.

CONCLUSIONS

The results of this study show that the effects of a Brain Gym® exercise-based program on the cognitive function and functional independence of institutionalized older adults with cognitive impairment are not significantly different from those obtained in a traditional fitness exercise training program.

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