Effect of Exercise on Cognition, Conditioning, Muscle Endurance, and Balance in Older Adults With Mild Cognitive Impairment: A Randomized Controlled Trial

Chandra da Silveira Langoni, PT, BSc[1]; Thais de Lima Resende, PT, PhD[2]; Andressa Bombardi Barcellos, PT, BSc[2]; Betina Cecchele, PT, BSc[2]; Mateus Soares Knob, PT, BSc[2]; Tatiane do Nascimento Silva, PT, BSc[2]; Juliana Nunes da Rosa, PT, BSc[2]; Tamiris de Souza Diogo, PT, BSc[2]; Irenio Gomes da Silva Filho, MD, PhD[1]; Carla Helena Augustin Schwanke, MD, PhD[1]

ABSTRACT

Background and Purpose: Mild cognitive impairment (MCI) may be a precursor to dementia; however, its progression may be prevented or slowed with exercise. This study aimed at determining the effects of group aerobic and strength training on cognition, conditioning, muscle endurance, and balance in underprivileged community-dwelling older adults with MCI.
Methods: This was a single-blind, randomized, and matched-pair controlled (gender, age, body mass index, and Addenbrooke's Cognitive Examination—Revised for MCI diagnosis) clinical trial. It was developed in 4 community centers. Fifty-two sedentary, functionally independent individuals, aged 60 years or more, with MCI were randomized into intervention group (n = 26) and control group (n = 26). Participants were tested before and after a 24-week exercise program. Sociodemographic characteristics, cognition (Mini-Mental State Examination), conditioning (2-minute stationary walk test), lower-limb endurance (30-second sit/stand test), and balance data (Functional Reach test) were collected. The intervention group walked and exercised twice weekly (60 minutes each) using ankle weights, latex resistance bands, and dumbbells. The exercise load and intensity were regularly increased on the basis of a preestablished incremental number of sets and repetitions and on the basis of the participants' correct movement execution with a given load. Data were analyzed with Pearson χ^2 test, Fisher exact test, Student *t* test, Mann-Whitney *U* test, 2-way repeated measures analysis of variance, and the Cohen *d*.
Results and Discussion: Before the intervention, no significant differences were found between groups for any of the variables. Postintervention, significant differences were observed in cognition, conditioning, muscle endurance, and balance. Significant time-by-group interactions were detected in all the intergroup analyses. The improvements observed in the intervention group had medium to large effect sizes (0.35-1.15). The control group's decrease in cognition (13.9%) had a large effect size, while its Functional Reach test decrease (11.4%) had a medium effect size, with no significant change in conditioning or muscle endurance.
Conclusion: The training program improved cognitive function, muscle endurance, aerobic conditioning, and balance in older adults with MCI.

Key Words: aged, muscle strength, postural balance, primary health care, public health

(*J Geriatr Phys Ther* 2019;42(2):E15-E22.)

[1]*School of Medicine, Pontifical Catholic University of Rio Grande do Sul, Porto Alegre, Brazil.*

[2]*School of Health Sciences, Pontifical Catholic University of Rio Grande do Sul, Porto Alegre, Brazil.*

This work formed part of the requirements for the doctorate degree of Ms Langoni, for which she received a tuition fees' grant from the Coordination for the Improvement of Higher Education Personnel (Coordenação de Aperfeiçoamento de Pessoal de Nível Superior—CAPES).

The authors declare that there are no conflicts of interest in regard to this article.

Address correspondence to: Thais de Lima Resende, PT, PhD, Pontifícia Universidade Católica do Rio Grande do Sul, Escola de Ciências da Saúde, Av. Ipiranga, 6690—Prédio 81—6° andar—sala 603, CEP: 90619-900, Porto Alegre/RS, Brazil (thaislr@pucrs.br).

Robert Wellmon was the Decision Editor.

DOI: 10.1519/JPT.0000000000000191

INTRODUCTION

Mild cognitive impairment (MCI) has been widely studied as a transitional cognitive disorder between the normal neurocognitive aging process and dementia.[1-5] According to the Alzheimer's Association,[6] half of individuals with MCI are likely to progress to dementia within 3 to 4 years.

One of the greatest risk factors for developing dementia is increasing age,[7] which underlies the reason why this disease is one of the most common issues in public health, given the rapid increase in the number of older individuals. In this sense, dementia requires increased attention, especially from public health managers, as it leads to increased morbidity in older adults, causes functional dependence,[8,9] and is the chronic noncommunicable disease that causes the most disability.[10]

Mild cognitive impairment, which may be a precursor of dementia, is also considered a health problem, due to its high rate of prevalence, varying between 15% and 20%.[4,5,11] In terms of the present study's location, a population-based study conducted with older public primary care users from socially vulnerable areas pointed to MCI having a frequency of 47.2%.[12] Despite this concerning scenario regarding the global and local occurrence of MCI, it is possible to reverse or reduce the chance of dementia onset in older adults through the use of various types of interventions.[2,13]

Thus, taking into consideration the possibility of slowing down or interrupting MCI's progression to dementia,[14] knowing its high local prevalence,[12] and understanding that users of public primary care units present with greater social, environmental, and health vulnerabilities,[15] a clear need is evident for preventive actions that prioritize low-cost measures and focus on strategies aimed at promoting the health of this population. Therefore, the present study aimed to evaluate the effects of group strength and aerobic training on the cognitive function, conditioning, muscle endurance, and balance of older adults with MCI living in vulnerable communities.

METHODS

This single-blind, randomized and matched-pair controlled (for gender, age, body mass index, Addenbrooke's Cognitive Examination-Revised score—ACE)[16] clinical trial was conducted with older users of 4 primary care units in Porto Alegre/RS, Brazil. It ran from October 2015 to March 2017 and was part of a larger research project. The larger project was approved by the Research Ethics Committee of the Pontifical Catholic University of Rio Grande do Sul (number: 427.997), complies with the Declaration of Helsinki, and was registered on the Brazilian Registry of Clinical Trials (number: RBR-6y2srf). All participants provided written informed consent. This study was conducted in 5 phases: (1) recruitment; (2) first battery of tests; (3) randomization; (4) intervention (24 weeks); and (5) second battery of tests.

Participants

The sample included sedentary individuals with MCI,[16] aged 60 years or older, independent in their activities of daily living, and able to travel to the training and testing site. The Katz Index[17] and Pfeffer's Functional Assessment Questionnaire[18] were administered to confirm independence in activities of daily living and the MCI diagnosis.[19]

Exclusion criteria included individuals with a history of severe psychiatric or neurological illness, including a history of stroke, transient ischemia, or traumatic brain injury; use of acetylcholinesterase inhibitors; current substance abuse; major communication deficiencies; simultaneous participation in other studies; regular physical activity (once a week during the last 3 months); physiotherapeutic treatment in the last 3 months; physical and functional limitations impeding physical activity; diseases that promote incapacity; severe visual deficiency; recurrent vertigo; and uncontrolled systemic arterial hypertension.

Recruitment Process

Participant recruitment occurred in 3 steps. Initially, the list of older users in each of the participating primary care units was accessed. Subsequently, the participants' medical records were checked for eligibility. Finally, home visits were made to the selected participants.

As seen in the Figure, a total of 2279 individuals were initially considered for recruitment and had their medical records checked for eligibility. Following this analysis based on the selection criteria, 886 individuals were excluded, leaving 1393 users who were selected for a home visit. Of these, 1125 were found at home, after up to

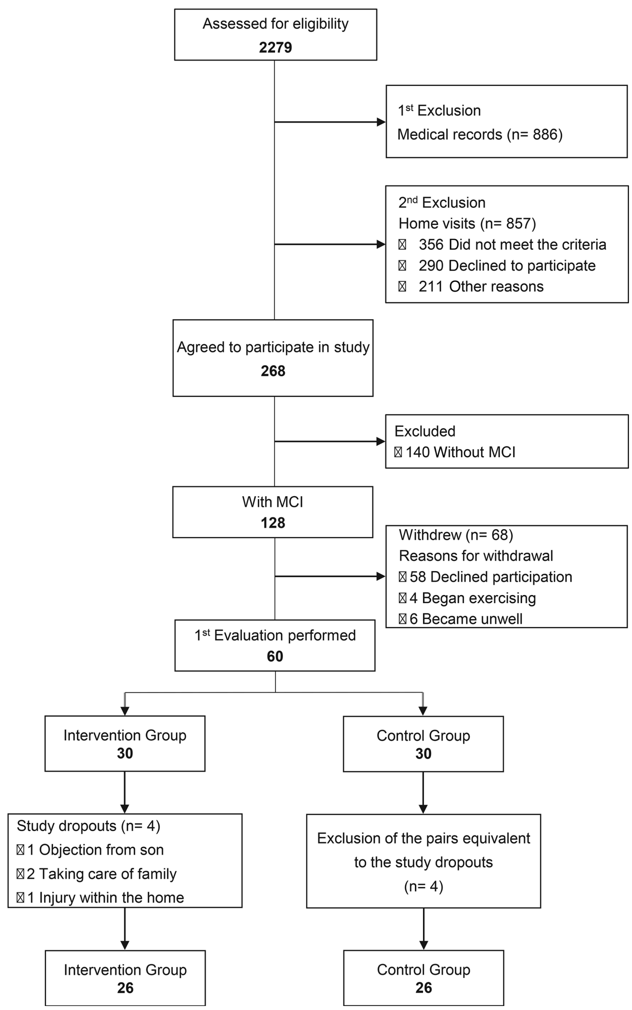

Figure. Flow diagram of the study's sample of older adults with MCI. MCI indicates mild cognitive impairment.

3 attempts. Among the people visited, 857 were excluded on the basis of the selection criteria or refusal to participate. Those eligible for the study provided written informed consent and completed the ACE. Subsequently, a further 140 individuals were excluded on the basis of their ACE scores.

A total of 128 older adults were invited to participate in the first battery of tests. However, in the time between agreeing to take part in the study and the first tests, a further 68 individuals were excluded: 58 declined to participate, 6 became unwell, and 4 began physical activity unrelated to the study. As a result, the final sample consisted of 60 participants.

Data Collection

Data collection and the intervention were conducted in community centers, public squares, and streets close to the participants' residences. Prior to data collection, researchers were trained in how to apply the tests and instruments. Immediately after collection, data were stored and the researchers involved with testing and training had no further access to it. Before and after the intervention, all tests were carried out by the same researcher, except for the Mini-Mental State Examination (MMSE), which was conducted by 5 researchers.

Sociodemographic data (gender, age, marital status, profession, race, religion, and schooling) and anthropometric data (weight and height) were collected. In addition, cognition (MMSE)[20] and a battery of tests and measures were implemented pre- and postintervention. Muscle endurance of the lower limbs was measured by the 30-second sit/stand test (sit/stand: number of times the person rises and sits in 30 seconds),[21] the 2-minute stationary walk test was used to assess aerobic conditioning (stationary walk: number of steps taken in 2 minutes),[21] and balance was assessed with the Functional Reach Test (FRT).[22]

The MMSE score was defined as the primary outcome. Secondary outcomes were based on the results of the sit/stand, stationary walk, and FRT tests.

Intervention

The intervention lasted for 24 weeks. After the first battery of tests, participants were paired and then randomly (computer-generated random number table) allocated into the intervention group (IG) or the control group (CG). Groups consisting of 5 to 8 participants took part in a twice-weekly group exercise session (approximately 60 minutes each), with load and intensity adjusted regularly (Table 1).[23] The CG was asked not to initiate any kind of physical or cognitive activity during the intervention. Regular telephone contact was maintained during the study to determine whether the CG participants engaged in any form of activity that was not part of their usual routine.

At all times, training sessions were conducted by a fully qualified physical therapist, who was aided by 2 physical therapy undergraduates in their last year at university. The undergraduate students helped the participants perform the exercise correctly. The physical therapist was responsible for individually assessing and progressing exercise load and intensity according to the training protocol (Table 1) and the participants' performance. At the beginning and the end of the exercise sessions, arterial blood pressure and radial pulse were measured and the participants performed stretching exercises. Once a week, participants wore a heart rate monitor to ensure training safety and maintenance of heart rate within individually determined training zones that were based on maximal predicted heart rate ($HR_{max} = 220 - Age$) (Table 1).[24]

The equipment used for the strength exercises included ankle weights, resistance latex bands, and dumbbells. Aerobic training involved 20 minutes of walking at 60% to 75% HR_{max} for the first 4 weeks, then gradually increased to 30 minutes by the 12th week (Table 1).[23] As the intervention progressed, maintenance of the HR at the training frequency was obtained with an increase in the walking speed, observed in the distance walked.

At the beginning of the study, phone calls were made to the IG participants to remind them of the scheduled training sessions. Any time a participant missed a session, an additional one was offered on a day outside their regular schedule.

In addition to the exercise routine, 2 types of social activities were also developed: 1 communal coffee per month, with the participation of the IG and the researchers responsible for training, and birthday celebrations occurring during the intervention. In both situations, the activities occurred shortly after the exercises.

Sample Size

The sample size calculations were made using the samples.exe software from the statistical package *Programs for EPIdemiologists* version 4. The calculations were based on the mean difference of the primary outcome (MMSE) between the groups at the end of the study, an α error of 5%, and an inference power of 97%. These showed that a minimum sample size of 26 participants in each group was required.

Blinding

Data were inserted in a spreadsheet where all variable labels were encoded to conceal their identification. Subsequently, the spreadsheet was sent to a statistician with no connection to the research group and without access to the variables' descriptions to perform the data analysis. After the data analysis was returned to the corresponding author, variables' encoding was reversed and the results were shared among the authors for the text's elaboration.

Statistical Analysis

Data were analyzed using the *Statistical Package for Social Sciences* version 20.0 (SPSS Inc., Chicago, Illinois). The Shapiro-Wilk test was used to investigate the distribution of continuous variables. The α level was set to .05.

The following tests (variables tested) were used: Student *t* test for independent groups assuming homogeneity of

Table 1. Training Protocol

Exercise	Material Used	Position	Weeks 1-6	Weeks 7-12
Strength Training (weeks 1-12)				
Elbow flexion	Elastic band	Seated	2 × 10 → 2 × 12 → 2 × 15 repetitions 1-min rest between sets Duration ≈30 min Neuromotor movement awareness/adaptation: low loads → load progression according to good performance of movement	2 × 15 repetitions + 6 s isometric contractions 1-min rest between sets Duration ≈30 min Load progression according to good performance of movement
Elbow extension				
Shoulder external rotation				
Shoulder abduction[a,b]				
Shoulder adduction[a,b]	Ball			
Shoulder internal rotation				
Hip adduction				
Hip abduction	Elastic band			
Knee extension	Ankle weights			
Knee flexion[a]		Standing		
Plantar flexion				
Squatting[a,c]	Body weight			
Strength Training (weeks 13-24)				
Exercise	**Material Used**	**Position**	**Weeks 13-18**	**Weeks 19-24**
Functional diagonals	Dumbbells	Standing	2 × 12 → 2 × 15 repetitions 1-min rest between sets Duration ≈30 min Load progression according to good performance of movement	2 × 15 repetitions + 6 s isometric contractions 1-min rest between sets Duration ≈30 min Load progression according to good performance of movement
Knee and hip flexion-extension[a]	Ankle weights			
Hip extension				
Knee extension		Seated		
Hip abduction[a]				
Hip adduction[a]				
Trunk flexion	Elastic band			
Plantar flexion	Ankle weights	Standing		
Squatting[a]	Body weight			
Sit/stand from a chair[a,d]				
Aerobic Training (weeks 1-24)				
Exercise	**Material Used**	**Weeks 1-7**	**Weeks 8-11**	**Weeks 12-24**
Walking	Heart rate monitor HR_{max} = 220 − Age	60%-75% 20 min	60%-75% 25 min	60%-75% 30 min

[a]Isometric exercises not performed.
[b]Started in the 7th wk (2 × 12 → 2 × 15).
[c]Started in the 11th wk (1 × 12 repetitions).
[d]Started in the 17th wk (1 × 15 repetitions); HR_{max}: Maximum heart rate. Stretches were performed at the beginning and end of each meeting.

variance (age, ACE, weight, height, MMSE after, sit/stand test after, and FRT after); Pearson χ^2 test with continuity correction (gender, marital status, and profession); Pearson χ^2 test (education); Fisher exact test with Monte Carlo simulation (self-declared ethnicity/race and religion); Student t test for independent groups assuming heterogeneity of variance (body mass index, MMSE before, sit/stand test before, and FRT before); Student t test for paired data (MMSE, sit/stand, and FRT); Mann-Whitney test (stationary walk test); and Wilcoxon test (stationary walk test).

Two-way repeated measures analysis of variance (ANOVA) was used to investigate the time-by-group interactions, with study of the sphericity assumptions (M Box and Mauchly tests). When the assumption of sphericity was not met, correction was made by the Greenhouse-Geisser Epsilon. Bonferroni correction was applied to adjust for multiple comparisons of the means for the main effects. Effect size was calculated using Cohen *d* test and classified as small (0.0-0.2), medium (0.3-0.5), and large (≥0.6).[25] To estimate the reliability coefficients for the only variable whose tests were carried out by different researchers, the MMSE, intraclass correlation coefficients, and 2-way analysis of variance (Participant × Researcher) were used.

RESULTS

Four members of the IG were excluded for reasons unrelated to the training program; consequently, the data for the 4 paired CG members were also excluded from the final analysis (Figure 1). Therefore, the final sample size consisted of 52 participants (IG: n = 26; 20 women and 6 men; 72.6 years [7.8]; CG: n = 26; 20 women and 6 men; 71.9 years [7.9]), with the majority being white, overweight, Catholic and female, with a low educational level, and who were not in a marital relationship (Table 2). All participants were independent in basic (Katz score ≥5)[17] and instrumental activities of daily living (Pfeffer score ≤ 2),[18] and the groups did not differ in terms of independence.

With a mean of 43 sessions attended out of the total 48 possible, the attendance at training sessions for the IG was high (89.5%). Half of the participants missed 7 sessions in 6 months, while the other half missed between 0 and 6 sessions.

The sample pairing in terms of age, gender, body mass index, and ACE achieved a balanced distribution as seen in Table 2. Preintervention, the groups did not differ significantly in the sociodemographic and anthropometric aspects (Table 2), cognition, or physical function (Table 3).

Postintervention (Table 3), a significant increase in the MMSE mean (14.2%) for the IG was detected, while a significant reduction (13.9%) occurred in the CG. A significant time-by-group interaction was detected ($F_{1,50}$= 113.54; $P < .001$; Power > 99.9%). A medium effect size in the IG (Cohen *d*: 0.657) and large effect size in the CG (Cohen: 0.85) were observed for the MMSE.

At the end of the study, a significant increase was noted in the number of steps taken by the IG participants (34.9%), while no significant change was detected in the CG compared with the initial values (Table 3). In addition, a significant time-by-group interaction was detected ($F_{1,50}$= 12.95; $P = .001$; Power = 94.2%). A large effect size was identified in the number of steps taken by the IG (Cohen *d*: 1.11) and small effect size in the CG (Cohen *d*: 0.18).

In the sit/stand test (Table 3), the IG mean at the end of the intervention increased by 24.7% (<0.001), while the

Table 2. Sample Baseline Characteristics

Variables	Group: Intervention (n = 26)	Group: Control (n = 26)	*P*
Age, y			
Mean (SD) (range)	72.6 (7.8) (60.7-88.3)	71.9 (7.9) (60.0-88.0)	.740[a]
Gender[b]			
Female	20 (76.9)	20 (76.9)	>.999[c]
Male	6 (23.1)	6 (23.1)	
Marital status[b]			
Living as a couple	11 (42.3)	8 (30.8)	.565[c]
Not living as a couple	15 (57.7)	18 (69.2)	
Profession[b]			
Work(ed)	19 (73.1)	19 (73.1)	>.999[c]
Never worked	7 (26.9)	7 (26.9)	
Addenbrooke's Cognitive Examination			
Mean (SD) (range)	55.0 (13.3) (41-79)	58.3 (12.6) (44-79)	.367[a]
Self-declared ethnicity/race[b]			
White	16 (61.5)	13 (50.0)	.775[d]
Black	6 (23.1)	10 (38.5)	
Brown[e]	3 (11.5)	2 (7.7)	
Indigenous	1 (3.8)	1 (3.8)	
Other			
Education[b,f]			
Illiterate	6 (23.1)	8 (30.8)	.798[g]
Primary	13 (50.0)	11 (42.3)	
Secondary	7 (26.9)	7 (26.9)	
Religion[b]			
Catholic	15 (57.7)	20 (76.9)	.223[d]
Evangelical	8 (30.8)	3 (11.5)	
Spiritualist	2 (7.7)	3 (11.5)	
Other	1 (3.8)		
Weight, kg			
Mean (SD) (range)	67.4 (14.2) (42.3-101.7)	65.4 (14.6) (39.0-93.1)	.615[a]
Height, m			
Mean (SD) (range)	1.56 (0.10) (1.40-1.77)	1.58 (0.10) (1.43-1.86)	.475[a]
Body mass index, kg·m^{-2}			
Mean (SD) (range)	27.8 (4.4) (17.0-37.1)	26.3 (5.1) (15.7-37.5)	.268[h]

[a]Student *t* test for independent groups assuming homogeneity of variance.
[b]Percentages obtained on the basis of the total of each group and presented as n (%).
[c]Pearson χ^2 test with continuity correction.
[d]Fisher exact test.
[e]Multracial Brazilian of brown skin color and mixed-race features, considering themselves to be "Pardos."
[f]Primary education: up to 8 years of schooling; secondary education: 9-11 years of schooling.
[g]Pearson χ^2 test.
[h]Student *t* test for independent groups assuming heterogeneity of variance.

Table 3. Cognitive and Functional Characteristics, Before and After the Intervention

Variables	Group: Intervention (n = 26)	Group: Control (n = 26)	Mean Difference (SD) (Intervention-Control)	*P*
Mini-Mental State Examination				
Before mean (SD) (range)	21.9 (4.8) (10.0-29.0)	23.7 (3.7) (16.0-30.0)	−1.8 (3.2)	.133[a]
After mean (SD) (range)	25.0 (4.7) (13.0-30.0)	20.4 (4.1) (13.0-28.0)	4.6 (3.3)	**<.001**[b]
Mean difference (before-after) (SD)	−3.1 (2.4)	3.3 (1.9)		
P[c]	**<.001**	**<.001**		
Stationary walk test[d,e]				
Before median (1st-3rd quartile)	97.5 (60.0-124.0)	102.0 (83.8-130.0)	−4.5 (13.3)	.390[f]
After median (1st-3rd quartile)	131.5 (105.0-153.8)	107.0 (96.3-130.3)	24.5 (16.3)	**.015**[f]
Mean difference (before-after) (SD)	−34.0 (36.9)	−5.0 (25.6)		
P[g]	**<.001**	.330		
Sit/stand test[h]				
Before mean (SD) (range)	9.3 (2.0) (6.0-14.0)	8.8 (2.1) (4.0-12.0)	0.5 (1.6)	.382[a]
After mean (SD) (range)	11.6 (2.0) (7.0-17.0)	9.0 (1.7) (5.0-12.0)	2.6 (1.4)	**<.001**[b]
Mean difference (before-after) (SD)	−2.3 (1.7)	−0.2 (2.2)		
P[c]	**<.001**	.723		
Functional Reach Test, cm				
Before mean (SD) (range)	28.1 (7.8) (14.0-46.0)	30.6 (8.2) (13.0-42.5)	−2.5 (4.8)	.268[a]
After mean (SD) (range)	30.7 (7.1) (15.5-44.0)	27.1 (6.9) (14.5-40.0)	3.5 (4.1)	.076[b]
Mean difference (before-after) (SD)	−2.6 (6.0)	3.5 (7.5)		
P[c]	**.036**	**.028**		

[a]Student *t* test for independent groups assuming heterogeneity of variance.
[b]Student *t* test for independent groups assuming homogeneity of variance.
[c]Student *t* test for paired data.
[d]Variable with asymmetric distribution.
[e]Stationary walk test—number of steps taken in 2 minutes.
[f]Mann-Whitney test.
[g]Wilcoxon test.
[h]Chair/stand test—number of times the person rises and sits in 30 seconds.

CG showed no significant change ($P = .723$). A significant time-by-group interaction effect was identified ($F_{1,50} = 14.80$; $P < .001$; Power = 96.5%). A large effect size was detected for the IG sit/stand test (Cohen *d*: 1.15), while a small effect size was noted for the CG (Cohen *d*: 0.10).

The IG and CG did not differ statistically on the FRT (Table 3), neither at the initial ($P = .268$) nor at the final ($P = .076$) evaluation. However, while there was a 9.3% increase ($P = .036$) in the IG at the end of the intervention, in the CG there was a 11.4% reduction ($P = .028$). Subsequent analysis detected a time-by-group interaction effect ($F_{1,50} = 10.31$; $P = .002$; Power = 88.3%). The calculations pointed to a medium effect size on the FRT for both the IG (Cohen *d*: 0.35) and the CG (Cohen *d*: 0.46).

The reliability coefficients for the mean MMSE scores showed that no significant between-researcher differences were detected in either the initial data ($P = .973$) or the final data ($P = .996$). Moderate to strong, significant, and positive intraclass correlation coefficients were found before (0.50-0.87) and after the intervention ($r = 0.51$-0.94), demonstrating consensus among the researchers and, consequently, lower error variance.

DISCUSSION

The older adults with MCI in the IG showed significant cognitive and functional improvement after 6 months of aerobic and strength exercise, with a medium-to-large effect size. At the same time, the CG presented with significant deterioration in cognition, with a large effect size, as well as a worsening of the FRT scores, while its conditioning and lower-limb muscle endurance showed no significant changes.

The number of studies focused primarily on the effects of aerobic conditioning on cognitive function in older adults with MCI[26-28] has been steadily increasing. In addition, although in a smaller quantity, the number of studies describing the effects of strengthening exercises in individuals with MCI is increasing.[29,30] However, several studies highlight the importance of randomized clinical trials that address the effects of combining both types of exercise on the overall cognitive function of older adults with MCI,[27,31] as developed in the present study. Nonetheless, these combined, randomized studies are still rare.

One such example is a study by Uemura et al,[32] developed with the same training frequency and duration as the present study. The authors observed an association between cognitive function and improved mobility but not muscle strength. In all likelihood, an association between strength and cognitive function was not found because they did not adopt a gradual, regular, and continuous load increase during training, as was the case in this study, where an average gain of 24.7% was observed in the IG's lower-limb muscle endurance.

Moreover, Iuliano et al,[27] who trained 3 groups randomized according to the type of exercise undertaken (muscle strength, cardiovascular or postural/balance), observed that the participants who performed strength and aerobic training showed significant improvements in their practical abilities, attention, and analytic tasks. Based on their results, the authors suggested that the effect of combining the 2 types of exercise should be further investigated. Thus, the implementation of strength and aerobic exercises, as carried out in our study, rather than their performance in isolation,[33] may lead to improved attention, processing speed, and practical abilities in older adults with MCI.[27]

Lü et al[29] also conducted research involving strength training in local community spaces and found improved cognitive function following training without load progression (36 sessions in 12 weeks). The authors also tested balance using the FRT and equally found no significant difference between the IG and the CG, either before or after the intervention. However, the present study detected a time-by-group interaction, as well as a significant increase in the IG's FRT mean after the intervention and a simultaneous significant reduction in the CG's FRT mean. This discrepancy in results between Lü et al[29] and the present study may be due to 3 factors: (1) the intervention duration and our number of training sessions were higher (48 sessions in 24 weeks); (2) exercise intensity was increased for strength training, and (3) the intervention included aerobic training.

The high-average exercise frequency rate (86.1%) detected by Lü et al[29] is a further common finding with the present study (89.5%). In addition to being developed locally, another possible explanation for our attendance rate could be the telephone contacts made by the researcher to those participants who missed an exercise session and the social activities developed (communal coffee and birthday celebrations). These may have led to the gradual creation of a bond, which resulted not only in high attendance but also in a low dropout rate among the IG (4/30). This greater frequency and consistency in training may have positively influenced the gains experienced by the participants in this study.[34] It is also possible that the small group size (5-8 participants), the social interaction resulting from group training, and the social activities helped group socialization, interaction and bonding, providing further stimulation, and aiding the improvement in the cognitive performance measures.[35]

In addition to the attendance rate, another aspect that may explain the success of our training program is the fact that the participants were continuously reminded to maintain the correct posture while exercising, as well as to be observant of both the correct number of sets and repetitions performed and the correct use of the different materials utilized (ankle weights, resistance bands, and dumbbells). This environment during training required IG members to use their attention, coordination, executive control, and spatiotemporal orientation, even though this was not our goal and we did not specifically evaluate those aspects. It is worth noting, nevertheless, that such actions may have indirectly led to the stimulation of executive functions and the performance of multiple tasks during the exercises.[29]

According to the findings from other studies,[28,36-38] it is possible that the benefits resulting from our exercise program go beyond those we investigated. The improvement of aerobic conditioning in older adults with MCI leads to neurophysiological alterations, such as increased hippocampal volume, gray matter,[36,37] and brain tissue plasticity.[28] The progressive increase in muscular endurance, on the contrary, may benefit the anti-inflammatory neurotrophic factor pathways, which in turn may be related to sarcopenia and cognitive decline.[38]

This study also included strategies aimed at minimizing possible biases, such as randomization; a parallel and paired CG that maintained its usual routine during the 6 months without engaging in any form of physical or cognitive activity; blinding of the professional who carried out the statistical analysis; training of the researchers who administered the tests; and the fact that the training sessions were conducted by the same researcher.

Despite the good results obtained, this study has some limitations, among them the fact that the sample came from a single city, which makes it difficult to expand the results beyond this population. Therefore, further studies such as this should be repeated in other locations. Another study limitation was the impossibility of making it double-blind, where the researchers who carried out the tests would not assist with the training sessions. Nonetheless, measures were taken to minimize this shortcoming by making sure that data collection was carried out without access to the previous results.

Future studies, however, should evaluate the benefits gained by different physical training regimens concomitantly associated with cognitive training. There are indications that, just as physical training demands specificity and load increase,[23] the same applies to cognitive training.[39] Nonetheless, attention should be paid to the way in which these 2 types of training are associated, as reported by Fiatarone et al.[30] These authors observed that, after a 6-month intervention, the older adults who carried out the combined training (exercise + cognitive training) showed significantly lower cognitive performance than did the group undertaking only resistance exercise. Without identifying a reason for such a finding, the authors hypothesized that the higher degree of challenge posed by the computer program used, the longer training sessions, and the shorter free time available for the other activities could have resulted in excessive stress, which inhibited rather than promoted the expected gains in neural plasticity and cognition.[30] However, based on the findings of Oswald et al,[39] consideration should be given to the fact that perhaps this age group requires more interpersonal contact. Even if the mechanism of this reduction in the benefit of combined training is as yet unknown, it remains a topic for future research.

CONCLUSION

Based on the results presented, we conclude that the group-based strength and aerobic training program resulted in improvements in cognitive function, muscle endurance, aerobic conditioning, and balance in older adults with MCI. Furthermore, this study showed that a community-based group exercise program is feasible and successful even in impoverished and socially vulnerable areas, using low-cost, easy-to-store equipment, and local public spaces near the participants' residences. However, to maximize the effectiveness of the intervention, the use of professional supervision to correctly prescribe and progress the exercise loads and intensities is critical.

REFERENCES

1. Feldman H, Scheltens P, Scarpini E, et al. Behavioral symptoms in mild cognitive impairment. *Neurology*. 2004;62(7):1199-1201.
2. Mirza SS, Ikram MA, Bos D, Mihaescu R, Hofman A, Tiemeier H. Mild cognitive impairment and risk of depression and anxiety: a population-based study. *Alzheimers Dement*. 2017;13(2):130-139.
3. Petersen RC, Caracciolo B, Brayne C, Gauthier S, Jelic V, Fratiglioni L. Mild cognitive impairment: a concept in evolution. *J Intern Med*. 2014;275(3):214-228.
4. Olsen K, Taylor JP, Thomas A. Mild cognitive impairment: safe to drive?*Maturitas*. 2014;78(2):82-85.
5. Yanhong O, Chandra M, Venkatesh D. Mild cognitive impairment in adult: a neuropsychological review. *Ann Indian Acad Neurol*. 2013;16(3):310-318.
6. Alzheimer's Association. 2013 Alzheimer's disease facts and figures. *Alzheimers Dement*. 2013;9(2):208-245.
7. Alzheimer's Association. 2016 Alzheimer's disease facts and figures. *Alzheimers Dement*. 2016;12(4):459-509.
8. Larson EB. Prospects for delaying the rising tide of worldwide, late-life dementias. *Int Psychogeriatr*. 2010;22(8):1196-1202.
9. Petersen RC. Clinical practice. Mild cognitive impairment. *N Engl J Med*. 2011;364(23):2227-2234.
10. Allegri RF, Butman J, Arizaga RL, et al. Economic impact of dementia in developing countries: an evaluation of costs of Alzheimer-type dementia in Argentina. *Int Psychogeriatr*. 2007;19(4):705-718.
11. Roberts R, Knopman DS. Classification and epidemiology of MCI. *Clin Geriatr Med*. 2013;29(4):753-772.
12. Nogueira GM, Schwanke CH, Closs VE, et al. Inflammation, oxidation, caloric expenditure and cognitive impairment in Brazilian elderly assisted at primary care. *Curr Alzheimer Res*. 2016;13(9):1056-1063.
13. Hayakawa T, McGarrigle CA, Coen RF, et al. Orthostatic blood pressure behavior in people with mild cognitive impairment predicts conversion to dementia. *J Am Geriatr Soc*. 2015;63(9):1868-1873.
14. Vidoni ED, Johnson DK, Morris JK, et al. Dose-response of aerobic exercise on cognition: a community-based, pilot randomized controlled trial. *PLoS One*. 2015;10(7):e0131647.
15. Brazilian Health Ministry. [*The Implementation of the Family Health Unit*]. Brasília, Brazil: Ministério da Saúde; 2000. http://bvsms.saude.gov.br/bvs/publicacoes/implantacao_unidade_saude_familia_cab1.pdf. [In Portuguese]. Accessed May 22, 2017.
16. Carvalho AV, Caramelli P. Brazilian adaptation of the Addenbrooke's Cognitive Examination—revised. *Dement Neuropsychol*. 2007;1(2): 212-216.
17. Wallace M, Shelkey M. Katz Index of independence in activities of daily living (ADL). *Urol Nurs*. 2007;27(1):93-94.
18. Pfeffer RI, Kurosaki TT, Harrah CH Jr, Chance JM, Filos S. Measurement of functional activities in older adults in the community. *J Gerontology*. 1982;37(3):323-329.
19. Albert MS, DeKosky ST, Dickson D, et al. The diagnosis of mild cognitive impairment due to Alzheimer's disease: recommendations from the National Institute on Aging-Alzheimer's Association workgroups on diagnostic guidelines for Alzheimer's disease. *Alzheimers Dement*. 2011;7(3):270-279.
20. Almeida OP. *Mini-exame do estado mental e o diagnóstico de demência no Brasil*. [*Mini-Mental State Examination and the Diagnosis of Dementia in Brazil*]. *Arq Neuropsiquiatr*. 1998;56(3B):605-612.
21. Rikli RE, Jones J. *Senior Fitness Test Manual*. Barueri, Brazil: Manole; 2008.
22. Duncan PW, Weiner DK, Chandler J, Studenski S. Functional reach: a new clinical measure of balance. *J Gerontol*. 1990;45(6):192-197.
23. Zijlstra A, Ufkes T, Skelton DA, Lundin-Olsson L, Zijlstra W. Do dual tasks have an added value over single tasks for balance assessment in fall prevention programs? A mini-review. *Gerontology*. 2008;54(1):40-49.
24. Fox SM, Naughton JP, Haskell WL. Physical activity and the prevention of coronary heart disease. *Ann Clin Res*. 1971;3(6):404-432.
25. Cohen J. *Statistical Power Analysis for the Behavioral Sciences*. 2nd ed. Hillsdale, NJ: Lawrence Erlbaum Associates; 1988.
26. Zheng G, Huang M, Li S, et al. Effect of Baduanjin exercise on cognitive function in older adults with mild cognitive impairment: study protocol for a randomised controlled trial. *BMJ Open*. 2016;6(4):e010602.
27. Iuliano E, di Cagno A, Aquino G, et al. Effects of different types of physical activity on the cognitive functions and attention in older people: a randomized controlled study. *Exp Gerontol*. 2015;70:105-110.
28. Suzuki T, Shimada H, Makizako H, et al. A randomized controlled trial of multicomponent exercise in older adults with mild cognitive impairment. *PLoS One*. 2013;8(4):e61483.
29. Lü J, Sun M, Liang L, Feng Y, Pan X, Liu Y. Effects of momentum-based dumbbell training on cognitive function in older adults with mild cognitive impairment: a pilot randomized controlled trial. *Clin Interv Aging*. 2015;11:9-16.
30. Fiatarone Singh MA, Gates N, Saigal N, et al. The Study of Mental and Resistance Training (SMART) study-resistance training and/or cognitive training in mild cognitive impairment: a randomized, double-blind, double-sham controlled trial. *J Am Med Dir Assoc*. 2014;15(12):873-880.
31. Kelly ME, Loughrey D, Lawlor BA, Robertson IH, Walsh C, Brennan S. The impact of exercise on the cognitive functioning of healthy older adults: a systematic review and meta-analysis. *Ageing Res Rev*. 2014;16:12-31.
32. Uemura K, Shimada H, Makizako H, et al. Cognitive function affects trainability for physical performance in exercise intervention among older adults with mild cognitive impairment. *Clin Interv Aging*. 2013;8:97-102.
33. Smith PJ, Blumenthal JA, Hoffman BM, et al. Aerobic exercise and neurocognitive performance: a meta-analytic review of randomized controlled trials. *Psychosom Med*. 2010;72(3):239-252.
34. Öhman H, Savikko N, Strandberg TE, Pitkala KH. Effect of physical exercise on cognitive performance in older adults with mild cognitive impairment or dementia: a systematic review. *Dement Geriatr Cogn Disord*. 2014;38 (5-6):347-365.
35. Train the Brain Consortium. Randomized trial on the effects of a combined physical/cognitive training in aged MCI subjects: the Train the Brain study. *Sci Rep*. 2017;7:39471.
36. Ahlskog JE, Geda YE, Graff-Radford NR, Petersen RC. Physical exercise as a preventive or disease-modifying treatment of dementia and brain aging. *Mayo Clin Proc*. 2011;86(9):876-884.
37. ten Brinke LF, Bolandzadeh N, Nagamatsu LS, et al. Aerobic exercise increases hippocampal volume in older women with probable mild cognitive impairment: a 6-month randomised controlled trial. *Br J Sports Med*. 2015;49(4):248-254.
38. Nithianantharajah J, Hannan AJ. The neurobiology of brain and cognitive reserve: mental and physical activity as modulators of brain disorders. *Prog Neurobiol*. 2009;89(4):369-382.
39. Oswald W, Gunzelmann T, Rupprecht R, Hagen B. Differential effects of single versus combined cognitive and physical training with older adults: the SimA study in a 5-year perspective. *Eur J Ageing*. 2006;3(4):179-192.