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Cognitive function in healthy elderly: secondary analysis of a randomized controlled trial comparing home-based exercises with virtual vs. message supervision

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Abstract

The study aimed to compare different supervision strategies during 12 weeks of a home exercise program on the cognitive function of healthy older adults. A clinical trial was conducted in which community-dwelling older adults of both genders participated. They were divided into two groups with different supervision strategies: those virtually supervised by videoconferences during all training sessions or those supervised by text messages. The intervention for both groups consisted of a program offered through video lessons, with a frequency of three weekly sessions and a duration of 12 weeks. Outcomes were assessed remotely via videoconference. The Montreal Cognitive Assessment (MoCA) was used to assess global cognition, and the Stroop test was used for inhibitory control. An intention-to-treat inferential analysis of mixed models by compound symmetry was performed, considering 95% confidence intervals (CI) and a significance level of 5%. Thirty-eight participants were randomized and allocated to one of the groups (81.6% women, mean age 68.39 ± 6.48 years, mean body mass 69.82 ± 12.15 kg, mean height 1.59 ± 0.06 m, mean body mass index of 27.82 ± 4.88 kg/m²; and 94.7% with more than 12 years of study). There were no statistically significant differences between groups (p>0.05), and no effects over time were observed in intra-group comparisons (p>0.05). It was concluded that both supervision methods used in this study did not provide additional cognitive gains to the home exercise program in healthy older adults.

Keywords: Aging. Cognition. Physical exercise for older adults. Supervised exercise.

INTRODUCTION

Cognition can be understood as a broad set of thinking skills involved in the knowledge acquisition process, which can be measured using performance-based tasks[1]. The aging process has a negative impact on cognitive function due to deleterious effects on the brain, such as reduced blood flow and structural changes[2,3]. Physical function is also affected with advancing age, such as reduced walking speed, which is also associated with worsening cognitive function in older adults[4].

Concerning cognitive function, evidence supports that physical exercise interventions positively affect the overall cognition and executive function of older adults already affected with some cognitive impairment due to advancing age[5]. The literature shows that regular practice of physical exercises in indi-

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viduals aged 60 years or older positively correlates with the maintenance or improvement of cognitive function. Studies also discuss the possible mechanisms by which the practice of physical exercises can improve cognition in older adults; among them are structural and functional correlations such as an increase in hippocampal volume, improvement in cerebral perfusion, and neural plasticity[6,7].

Considering the importance of creating proposals to encourage an active lifestyle in older adults, home exercise programs appear as a simple, effective, viable, and safe option to maintain the benefits obtained in specific environments for physical activities with the supervision of professionals[8]. Home exercise programs have an excellent cost-benefit ratio[9] and may mitigate some barriers to the practice of physical exercises by older adults, such as the need to travel[10]. Furthermore, studies suggest that home exercise programs can improve cognition and reduce the risk of dementia[10,11].

Recently, the practice of home exercises was widely recommended during the context of social isolation resulting from the new coronavirus (COVID-19) pandemic, mainly aimed at protecting groups at greater risk for the disease, such as older adults[12]. In this scenario, home exercise programs and online classes were identified as the primary global fitness trends[13]. However, one of the main characteristics of home exercise programs is the absence of supervision and/or minimal supervision. This fact represents a disadvantage in relation to the magnitude of potential benefits[14].

Given the above, virtual supervision via videoconferences can be a factor that enhances results, as well as face-to-face supervision, as it is an interesting strategy for improving results by promoting stimuli that favor the execution of exercises and responses to training[9]. Thus, investigating and understanding the effects of adding virtual supervision in home exercise programs on the cognitive function of older adults is relevant. The present randomized clinical trial aims to compare different supervision strategies during 12 weeks of a home exercise program on the cognitive function of healthy older adults.

METHODS

Study design and ethical aspects

This is a secondary analysis of a superiority randomized clinical trial with parallel groups, with an allocation ratio of 1:1, recorded in the Brazilian Registry of Clinical Trials (RBR-8qby2wt), prepared according to CONSORT recommendations. The study was carried out using virtual platforms, especially videoconferencing, with two evaluation times (baseline and 12 weeks) for three cognitive function outcomes. The Research Ethics Committee of the Federal Rural University of Pernambuco approved the research under opinion number 4.613.968.

Participants

Participants were recruited voluntarily and digitally from June 2021 to January 2022. The older adults were literate community members with sufficient visual and auditory capacity to participate in the study, authorized by professionals to practice exercises at home, and not involved for at least six months in a physical exercise program, lacking a diagnosis of cognitive impairment and/or mental health disorders, and had a minimum Montreal Cognitive Assessment (MoCA) sco-

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re of 19 points performed by video call and adjusted based on the Brazilian population for screening light cognitive impairment[15–17].

For inclusion in the study, it was also necessary to have access to at least one electronic device with a front camera, microphone, messaging applications, video calls and video platforms, and an internet connection with stability and sufficient speed for videoconference transmissions.

As exclusion criteria, it was established that participants affected by some limiting condition during collections and/or who engaged in another physical exercise program in parallel with the study would be excluded from the research.

Interventions

The same exercise protocol was shared between the participants in the group with virtual supervision and the group supervised by text messages. The only differences were that the virtually supervised group carried out the training sessions with supervision by videoconference with a Physical Education professional. Meanwhile, the second group performed the exercises with the help of a video-sharing site, followed virtually by researchers through messaging applications and phone calls to control adherence and frequency for 12 weeks. The training consisted of a 30–40-minute session, held three times a week, consisting of 10 home exercises with body weight as resistance to increase muscle strength and endurance and work on mobility and flexibility.

Initially, for two weeks before being allocated to the groups, each participant underwent supervised familiarization once a week, individually in the first week and collectively in the second, with up to 6 users per call. The exercises had two sets of 8 to 10 repetitions, with a rest interval of 30 seconds in the warm-up and 1 minute during the main exercises. The exercises performed were as follows: standing hip and shoulder mobility; push-ups on the wall; sit and stand up from a chair with support; sit-ups with arms on the shoulder; standing hip abduction; pelvic elevation; plantar flexion; unilateral infra-abdominal exercise; and lying single leg hug.

After familiarization, allocation took place, and the home exercise program lasting 12 weeks was started (Charts 1 and 2), based on two systematic reviews with meta-analysis on home training programs[9,14] and physical activity recommendations during the COVID-19 pandemic of the American College of Sports Medicine[18]. Interventions could be modified or interrupted at the request of the participants if they reported any discomfort or worsening of their health condition.

Chart 1 – Intervention protocol. Recife, Pernambuco, 2022.

Training	Weeks	Frequency	Series	Repetitions	Interval	
					Warm-up	Main part (min)
Familiarization	2 Weeks	3x/week	2	8-10	30”	1’
Training program itself						
Workout 1	1-8		3	8-10	30”	1’
Workout 2	9-12	3x/week	4	8-12	30”	1’

Note: Isometric exercises will have a 20 to 30” margin of execution.

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Chart 2 – Description of the training. Recife, Pernambuco, 2022.

Familiarization	Workout 1	Workout 2
Standing hip mobility	Standing hip mobility	Quadriceps stretch
Shoulder mobility	Shoulder mobility	Shoulder mobility
Push-ups on the wall	Push-ups with knee support	Arm flexion without support
Sitting and standing up from a chair with support	Sitting and getting up from a chair without support	Free squat
Sit-ups with arms on shoulders	Sit-ups with arms outstretched	Abdominal plank
Standing hip abduction	Lying hip abduction	Standing one-sided hip flexion
Pelvic lift	Pelvic lift	Unilateral pelvic lift
Plantar flexion	Isometric plantar flexion	Unilateral plantar flexion
Abdominal infra unilateral	Abdominal plank	Sit up with arms outstretched
Lying single-leg hug	Lying single-leg hug	Sitting hamstring stretch

In blue: warm-up phase; in yellow: main part; and in green: cool-down activities.

Outcomes

Videoconferencing assessed Cognitive function remotely, considering two outcomes: overall cognition and inhibitory control. The evaluation procedures, including adaptations made and values of reproducibility and reliability of the measurements, were detailed in a specific article by Silva *et al.*[19].

The Montreal Cognitive Assessment (MoCA) was used to assess global cognition. It is a brief screening instrument that assesses a wide range of cognitive functions (such as executive functions, visuospatial skills, naming, memory retrieval, verbal fluency, abstract reasoning, and orientation) and is widely used to contribute to the diagnosis of mild cognitive impairment (MCI) and dementia[16]. The application of the test was adapted for a remote scenario, following the MoCa recommendations for application by videoconference[17]. The participant was asked to change the camera's direction when carrying out manual tasks to view and evaluate the activity when necessary.

To assess inhibitory control, the Stroop test was used. It is a neuropsychological test of attention to simultaneous tasks: one reading and another naming colors[20]. The test was adapted for remote application via videoconference. For this purpose, the three test conditions (naming colors, reading words, and reading words in incongruous colors) were applied by sharing images containing six lines with four items. The first image was composed of colored circles; the second consisted of neutral words written with the colors of the circles; and the third had the names of colors written in conflicting colors. As quickly as possible, the subject was asked to verbalize the colors of the circles, the words, and, finally, the colors of the words filled with incongruous colors for each image presented. The time the subject needed to fulfill the instructions for each task was recorded. Subjects were evaluated according to how quickly they performed the tasks and the number of errors presented. The effect of interference or the Stroop effect was determined by calculating the extra time required to name colors compared to the time required to name colors in the first task, which was the control colors of circles[21].

Sample size

The minimum a priori sample size of 34 people was calculated using the G*Power 3.1 software and using the inter-intragroup interaction ANOVA group with the following

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input parameters: effect size of 0.25; type I error equal to 0.05; type II error equal to 0.80; and number of groups equal to 2 and number of measurements equal to 2. A standard correlation between measures of 0.50 and a dropout rate of 20% was also used to compensate for possible sample losses. Using an effect size of 0.25 was based on a similar study conducted by Lacroix *et al.*[22] that investigated the effects of minimally supervised home exercises on healthy community-dwelling older adults compared to an unsupervised model.

Randomization and blinding

Older adults who met all inclusion criteria (n = 38) after online screening by questionnaires and videoconferencing were randomized into one of two groups (home exercise group with virtual supervision and home exercise group supervised by text messages) using computer-generated numbers (www.randomizer.org) after signing the informed consent form. Allocation was blind and performed by a researcher not involved in the evaluation and intervention, with a simple distribution strategy (1:1), where participants had equal chances of allocation. After the allocation, the evaluators were blinded regarding the intervention, and the researcher responsible for the statistical analysis was also blinded.

Statistical analysis

Data were processed and analyzed using IBM SPSS Statistics 25.0 and Microsoft Excel 2019 programs. Data were represented by measures of central tendency and dispersion (mean and standard deviation) or in percentage values, with data normality assessed using the Shapiro test Wilk and the similarity analysis of the groups at baseline performed by the Mann-Whitney test.

Repeated measures were evaluated by mixed model analysis using General Mixed Models (GMM) equations through composite symmetry models. Data were adjusted for age, sex, and education. All participants who entered the study were included in the analysis of effects on cognitive functions (intention-to-treat analysis by multiple imputations of up to 5 levels).

To examine the magnitude of change, the means from the final assessment were subtracted from the baseline means. In all analyses, confidence intervals (CI) were considered at 95% with a significance level of 5%. In the case of effect observation, the Sidak post hoc test was chosen.

RESULTS

Figure 1 shows the flowchart of the participants during the study. Recruitment and follow-up periods took place from June 2021 to January 2022. Of the 77 volunteers who underwent the initial screening, 35 did not meet the inclusion criteria or withdrew in advance from participating. Thus, 38 volunteers were randomized and allocated to one of the experimental conditions. The virtually supervised group had 18 participants, and the group supervised by text messages had 20 participants. During the intervention, there were two losses in the virtually supervised group; in both cases, the losses occurred at the end of eight weeks of intervention. There were two dropouts in the group supervised by text messages, one during familiarization and the other at the end of eight weeks of training (Figure 1).

The sample consisted, in general, of older adults with more than 12 years of schooling, within the normative score of the MoCA readjusted for the Brazilian population and a normal classification of mental health and mood profile indicators. There was a discrepancy between the groups regarding the frequency rate (Table 1).

The groups were similar in terms of per-

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formance values in the cognitive domains at baseline at all moments (Table 2).

The main results did not show a statistically significant effect of virtual supervision for any of the outcomes, both for the intervention analysis and for the time analysis (Table 3).

Figure 1 – Flowchart of study participants. Recife, Pernambuco, 2022.

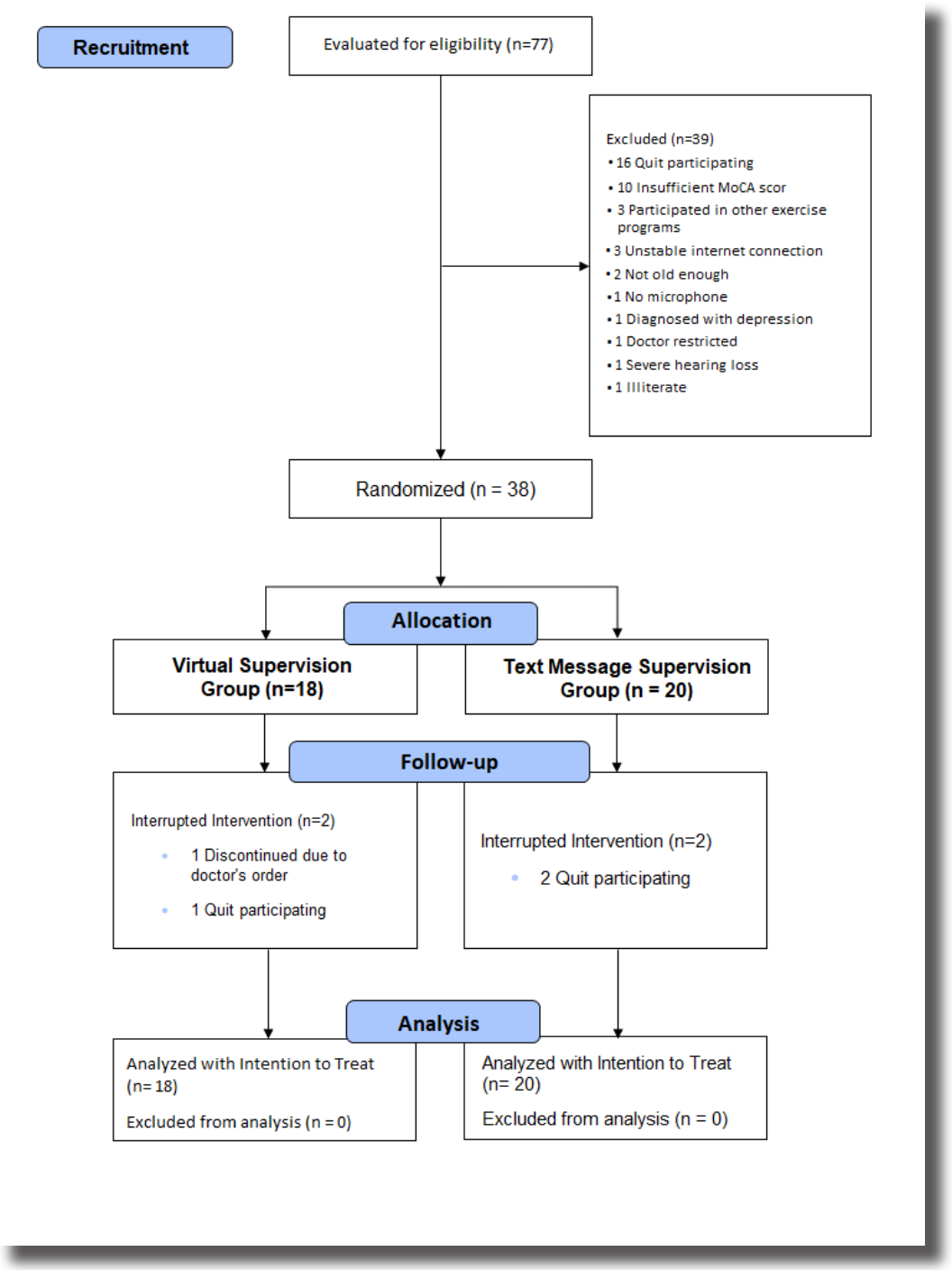

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Table 1 – Descriptive data of the participants according to the group at baseline. Recife, Pernambuco, 2022.

Variables	Sample Total	Virtual Supervision Group	Text Message Supervision Group	p
	(n = 38)	(n = 18)	(n = 20)	
Gender, n (% women)	31.00 (81.60)	15 (83.30)	16.00 (80.00)	0.794
Age, mean (SD), yearsa	68.00 (6.48)	68.00 (5.88)	69.00 (7.05)	0.725
Body mass, mean (SD), kg[a]	69.82 (12.15)	71.91 (10.48)	67.94 (13.46)	0.286
Height, average (SD), ma	1.59 (0.06)	1.59 (0.07)	1.58 (0.06)	1.000
Body mass index, mean (SD), kg/m²	27.82 (4.88)	28.52 (4.14)	27.19 (5.49)	0.397
Sarcopenia risk, mean (SD), scoreb	1.38 (1.12)	1.56 (1.15)	1.10 (1.07)	0.184
Average attendance rate for training, %	72.44 (26.15)	60.65 (25.19)	83.06 (22.65)	0.001*
Education, n (%)				
≥ 12 years	36.0 (94.7)	17.0 (94.4)	19.0 (95.0)	0.940
Regions of Brazil, n (%)				
Northeast	35.0 (92.1)	16.0 (88.9)	19.0 (95.0)	0,491
Southeast	3.0 (7.9)	2.0 (11.1)	1.0 (5.0)	
Health conditions[a], n (%)				
Fell in the last year	10.0 (26.3)	6.0 (33.3)	4.0 (20.0)	0.358
Hypertensive	8.0 (21.1)	6.0 (33.3)	2.0 (10.0)	0.082
Diabetics	2.0 (5.3)	1.0 (5.6)	1.0 (5.0)	0.940
Musculoskeletal problems	11.0 (28.9)	8.0 (44.4)	3.0 (15.0)	0.049*
Heart problems	3.0 (7.9)	1.0 (5.6)	2.0 (10.0)	0.617
Use of medication for comorbidities	12.0 (31.6)	7.0 (38.9)	5.0 (25.0)	0.364
Internet environment and technologies, n (%)[a]				
Experience with video conferencing features	29.0 (76.3)	14.0 (77.8)	15.0 (75.0)	0.843
Full familiarity with the internet and technologies	12.0 (31.6)	6.0 (33.3)	6.0 (30.0)	
Uses the internet and technologies on a daily basis, but with difficulties	25.0 (6.8)	11.0 (61.1)	14.0 (70.0)	0.972
No familiarity with the internet and technologies	1.0 (2.6)	1.0 (5.6)	0.0 (0.0)	

SD: Standard deviation.
[a]Data self-reported by participants.
[b]Data obtained by applying the sarcopenia screening questionnaire (SARC-F) with a score ≥ 4 indicating risk of sarcopenia.
*Statistical difference.

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Table 2 – Mean values of cognitive assessments at different times. Recife, Pernambuco, 2022.

	Virtual Supervision Group (n = 18)		Text Message Supervision Group (n = 20)	
Cognitive assessments	**Baseline**	**12 weeks**	**Baseline**	**12 weeks**
MoCA, score	23.57 (1.11)	23.14 (1.11)	22.91 (0.87)	23.59 (0.87)
Stroop test (color condition), seconds	19.17 (1.42)	20.75 (1.42)	17.41 (1.13)	18.82 (1.13)
Stroop test (reading condition), seconds	13.61 (1.69)	14.48 (1.69)	14.01 (1.34)	14.44 (1.34)
Stroop test (interference condition), seconds	32.73 (3.95)	31.49 (3.95)	35.24 (3.15)	40.14 (3.15)
Stroop test (Stroop effect), seconds	13.57 (2.22)	14.01 (2.22)	17.82 (1.77)	15.44 (1.77)

Average values (standard deviation).

Table 3 – Effects of the intervention on the participants' cognitive outcomes. Recife, Pernambuco, 2022.

	Mean difference between baseline and 12 weeks (95% CI)		Inter-group comparison (12 weeks)
Cognitive assessments	**Virtual Supervision Group (n = 18)**	**Text Message Supervision Group (n = 20)**	**Virtual Supervised Group - Text Message Supervision Group**
MoCA, score	-0.43 (-2.51 to1.65)	0.68 (-0.98 to 2.34)	-0.45 (-3.38 to 2.49)
Stroop test (color condition), seconds	1.57 (-0.69 to 3.84)	1.41 (-0.40 to 3.22)	1.93 (-1.87 to 5.71)
Stroop test (reading condition), seconds	0.87 (-1.20 to 2.94)	0.43 (-1.22 to 2.09)	0.04 (-4.48 to 4.55)
Stroop test (interference condition), seconds	-1.24 (-8.85 to 6.37)	4.89 (-1.18 to 10.96)	-8.65 (-19.10 to 1.80)
Stroop test (Stroop effect), seconds	0.44 (-4.88 to 5.76)	-2.38 (-6.63 to 1.87)	-1.42 (-7.23 to 4.38)

CI: Confidence Interval. Values in mean difference (confidence interval). Data analyzed with composite symmetry model.

DISCUSSION

This randomized clinical trial aimed to compare different supervision strategies during 12 weeks of a home exercise program on the cognitive function of healthy older adults. One group was virtually supervised during all training sessions, and the other was minimally supervised by messages and phone calls. At the end of the intervention, no differences were observed between the groups for any of the analyzed outcomes.

The results indicate that supervision itself may not be the main factor in generating change. Still, it is important to consider that, given the cognitive profile of the older adults at baseline, the margins for possible gains promoted by home exercise interventions in the evaluations of specific domains of cognitive function were small. Moreover, the older adults in this sample had a good cognitive function before the intervention (good level of education, internet access, and technologies, among others), which may have impacted the dimension of cognitive gains[23]. In addition, there was the possibility

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of observing effects considering the duration of 12 weeks, although studies suggest that at least 24 weeks of exercise are necessary to detect cognitive alterations. However, in tests with a shorter time, alterations in brain function have also been demonstrated[24].

According to the guidelines in the literature, the addition of supervision by a professional can enhance the results by ensuring maximum control over the conduction of the exercise session[9,22]. However, in the present study, the virtual supervision format was not enough to promote motor and procedural requirements that could improve cognition compared to a model of minimal supervision.

One of the explanations for not observing the superiority of virtual supervision compared to the minimal supervision may be the reduced frequency rate. Still, despite a considerably lower training frequency (approximately 25%), participants in the virtually supervised group achieved similar gains as the minimally supervised group. This fact suggests that supervision can promote superior responses in conditions where the total frequency of sessions is equal or even in longer interventions.

A possible mistaken analysis of the references on the effect of supervision in the exercises is also pointed out because the results may suffer a more direct influence of other training variables, such as the control of the intensity, volume, and other determinants of the prescription. These factors can be better controlled in more structured environments for the practice of exercises, with ample conditions of equipment and other resources[25]. Therefore, we are cautious in extrapolating the results attributed to the supervision method itself, as the effects of exercise are directly related to the prescription parameters and not the form of supervision.

Comparing the results over time with similar studies, Öhman *et al.*[26] observed improvements in the executive function of older people with memory disorders. However, the effects were mild, and no effects were observed in other domains of cognition, mainly in verbal fluency. Another study verified that the implementation of the home exercise program promoted an increase in the cognitive response of older adults, especially their executive function, and even reduced the number of falls of the participants[27].

In a study conducted by Nemček & Simon[28], pre- and post-intervention comparisons pointed to a 69% improvement in the time involving all three conditions of the Stroop test. Still, only the score on the reading condition showed a statistically significant increase, where 88% of the seniors improved their time score. Finally, results were also found in treatment approaches for dementia with physical exercises at home, similar to the cognitive increase demonstrated in the present study, although not significant[29].

In general, the positive effects of home exercises in older adults specifically focused on the development of muscle strength and endurance adopted in the study, are justified by its potential to improve cognitive functioning in healthy and clinical populations[30,31]. There is also increasing evidence to suggest that these interventions focused on strength development, even when performed acutely, which can lead to positive neuroplastic changes in the central nervous system and improve cognitive functioning[32–38]. This contributes to better learning, memory, and attention, while decreasing the risk of falls with the attenuation of cognitive impairment associated with advanced age[39]. Thus, exercises that improve muscle strength and endurance have been proposed as a rehabilitation strategy in populations suffering from neurological or neurocognitive deficiencies or even to attenuate the decline in cognitive health[33].

The study's strengths include the rigorous methodology, as it is a randomized controlled study, and compliance with the recommendations for the type of study, except for those that were not possible due to the remote nature of the study. The novelty of this study

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stands out due to the breaking of geographic barriers before the application of interventions by virtual supervision and cognitive assessments remotely by videoconference, where it was possible to promote social interactions and interventions in a simple way, which could be easily performed in an environment home by the older adults public, generally without familiarity with the technology.

It is important to emphasize that the study has some limitations, such as the different frequency rates between the groups. As the trial's primary outcomes were directed at physical/functional aspects, some decisions about planning interventions may have needed to be deeper in targeting cognitive responses. Another point is the interference caused by limitations of home exercise programs[40], such as the use of one's own body weight as a load for resistance, without adding external loads. This aspect limits the application of more intense stimuli to induce statistically detectable cognitive changes. The same occurs in relation to the training volume, which tends to be lower since the training volume is the product of the load by the number of total repetitions performed during the session[41].

Finally, despite the use of cognitive tests known in the literature and evidence supporting the videoconference format for teleneuropsychological assessments in the older adults[42-44], the accuracy of measurements for all cognitive tests when applied virtually via videoconferencing is still questionable[42]. Thus, the use of evaluations in a remote format is a limitation of the method adopted to screen and control participants. Therefore, the lack of standardized and widely used assessments in this remote format may have some influence on the results. It is suggested that future studies improve the investigation of supervision, including adding a control group, which was a limitation herein, and comparing face-to-face and virtual supervision modalities.

CONCLUSION

Since The two programs did not improve the cognitive function of the older adults, it is concluded that virtual supervision of a home exercise program over 12 weeks promotes similar cognitive responses to an exercise program supervised by text messages and phone calls in physically healthy older adults possessing no impairment in cognitive function.

Altogether, the older adult population should be encouraged to engage in either of the two home exercise programs regularly. As for practical implications, proposals for home exercise can be improved with remote supervision in real-time by videoconferencing, allowing benefits usually obtained with face-to-face training. Such findings impact the way personalized training services are offered and the recommendations for the practice of exercises in general, in different contexts.

Author Statement CREdiT

Conceptualization: Silva, JDA; Maranhão, DCM; Piraua, ALT. Methodology: Silva, JDA; Maranhão, DCM; Piraua, ALT. Validation: Silva, JDA; Maranhão, DCM; Piraua, ALT. Statistical Analysis: Silva, JDA; Piraua, ALT. Formal analysis: Silva, JDA; Maranhão, DCM; Piraua, ALT. Research: Silva, JDA; Maranhão, DCM; Piraua, ALT. Resources: Silva, JDA; Maranhão, DCM; Piraua, ALT. Original-written preparation: Silva, JDA. Writing: Maranhão, DCM; Piraua, ALT. Visualization: Silva, JDA; Maranhão, DCM; Piraua, ALT. Supervision: Piraué, ALT. Project Manager: Piraué, ALT.

All authors read and agreed with the published version of the manuscript.

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