ORIGINAL RESEARCH

Effects of 12-Weeks of Home-Based Exercise Training on Physical and Cognitive Function of Older Adults: Randomized Trial Comparing Virtual Versus Minimal Supervision in the Context of the Covid-19 Pandemic in Brazil*

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ABSTRACT

Background

We investigated the effects of a 12-week home-based exercise program delivered with virtual or minimal supervision on the physical and cognitive function of community-dwelling older adults in the context of the COVID-19 pandemic in Brazil.

Methods

The study was registered on the Brazilian Registry of Clinical Trials platform (code: RBR-8qby2wt). Thirty-eight older adults (81% female and 68±7 years old), non-disabled, and without cognitive impairment or dementia, were randomly assigned to a 12-week home-based exercise program: 1) virtual supervision (classes remotely delivered through video conference by trained staff), or 2) minimal supervision (once-weekly contact to touch base through standardized text messages). The participants initially performed two sets of 10 repetitions three times a week, with a 60-second interval. The volume and complexity of the exercises were progressively increased. (e.g., the number of sets increased to 3 and later to 4). At baseline and follow-up, we collected remote measurements of physical function (muscle strength and power, functional muscular fitness) and cognition (processing speed, inhibitory control, verbal fluency).

Results

Participants in the minimal supervision home-based exercise group significantly improved the Stroop test (-1.6 sec, 95% CI = -3.20; -0.09). No significant between-group differences were observed for physical and cognitive outcomes.

Conclusion

A home-based exercise program delivered with virtual or minimal supervision can produce similar effects, and may help to maintain physical and cognitive capabilities among healthy, high-functioning older adults who experienced mobility restrictions due to the COVID-19 pandemic in Brazil.

Key words: home-based exercise, functional mobility, cognition, web-based intervention, aging

INTRODUCTION

Community-dwelling older adults experienced a 15–25% decrease in physical activity levels during the COVID-19 pandemic.(1,2) As well, it is also important to note that aging undermines muscle strength and power, functional mobility, flexibility,(3-5) cognitive function, and fear of falling.(6) These alterations have a negative impact on the indices of functional capacity, which have been associated with a higher risk of frailty, disability, and premature death.(7)

In the COVID-19 pandemic, home-based exercise (HBE) programs emerged as a feasible alternative to mitigate or improve daily function and mobility in the older population.(8-10) HBE programs commonly include functional

*A reliability and feasibility study has been previously published: "Videoconference assessment of functional and cognitive measures in Brazilians older adults: a reliability and feasibility study." DOI: 10.53886/gga.e0230002 exercises and can be delivered using different approaches including unsupervised, minimally supervised, or facilitated protocols.(11) However, a systematic review with meta-analysis showed that supervised exercise sessions yield superior results than unsupervised ones.(10) Supervision allows better training progression (e.g., volume and intensity) and participants' safe monitoring.(12,13) Emerging evidence suggests that even without direct supervision, HBE may effectively promote muscle strength and power gains, better postural balance,(10) and prevent mood and cognitive decline.(8,14)

Given the impossibility of professional monitoring of sessions during the pandemic, using technology may be a viable alternative. Virtual supervision via videoconferencing enables the execution of HBE programs with online supervision in real time. Furthermore, conducting remote HBE could enhance the adherence of older adults by minimizing barriers to the practice of physical activity during the COVID-19 pandemic. (15) With this in mind, the purpose of this study was to compare the effects of an HBE training program delivered with a virtual or minimal supervision approach on physical and cognitive function in community-dwelling older adults. We hypothesized that the supervised exercise program would yield more significant physical and cognitive gains in older adults.

METHODS

Study Design and Ethical Aspects

This is a randomized clinical trial with two parallel groups, with an allocation ratio of 1:1. The study received approval from the local Ethics and Research Committee (protocol no. 40759120.2.0000.9547), and signed informed consent was obtained from all participants. The trial protocol was prospectively registered on the Brazilian Registry of Clinical Trials (REBEC) platform under the code RBR-8qby2wt. Trial reporting was prepared in accordance with Consolidated Standards of Reporting Trials (CONSORT) recommendations.

Participants were recruited from the community between June 2021 and January 2022 using several strategies, including social media platforms (e.g., Instagram, Facebook), local TV, and radio.

Participants and Eligibility

This study included nondisabled older adults aged 65 years and older who met the following inclusion criteria: (a) did not perform structured physical activity (e.g., progressive resistance training) in the previous six months; (b) having at least one electronic device with a frontal camera and internet access; (c) having adequate visual and auditory capacity to follow the training program; and (d) having support, if needed, from someone who could assist in the use of electronic devices in case of technical issues.

We excluded participants who had signs, symptoms, or health issues that would preclude their participation in home-based exercise, such as unstable coronary heart disease, angina pectoris, uncontrolled hypertension, diabetes, knee osteoarthritis resulting in severe functional impairment. Complementary exclusion criteria included not regularly using medications that could impair functional mobility and cognition (e.g., antiemetics or proton pump inhibitors)(16) and not achieving a minimum score of 19 points on the remote version of the Montreal Cognitive Assessment (MoCA).(17,18)

Randomization and Allocation of Participants

Participants were randomized (by a researcher not directly involved in recruitment or data collection) using an open, web-based system (https://www.randomizer.org) to generate the codes. Allocation was concealed from the researchers conducting the measurements.

Experimental Procedures, Run-in Phase, and Interventions

Before the randomization procedures, eligible participants underwent a two-week run-in phase to familiarize themselves with home-based exercises using the Google Meet platform (groups of six participants). Over this period, we delivered three sessions per week on non-consecutive days, totaling 25 minutes. Each session included the following phases: 1) warm-up phase, with exercises targeting hip and shoulder mobility; 2) main phase with seven weight-bearing exercises (push-up arm, sit and stand up from a chair, abdominal flexion, lying hip abduction, pelvic lift, isometric plantar flexion, plank exercise) for the main muscular groups.(7-9) The exercises were performed in two sets of 10 repetitions with a 60-second interval, except for the plank exercise (15 sec of core stability), and 3) cool-down phase with light-intensity movements to promote and reduce physiological responses (e.g., heart rate).

Subsequently, participants were assigned to one of two study arms to receive three sessions per week, virtual or minimally supervised home-based exercise training over 12 weeks. Both groups performed the same exercise protocol practiced during the familiarization sessions. In both groups, participants initially performed two series of 10 repetitions with a 60-second interval that progressively increased in terms of volume (e.g., the number of series increased to 3 and later to 4) and complexity (exercises guided by some implement, e.g., chair, were freely executed). The main difference between the experimental groups was that a certified exercise science professional delivered all virtually supervised group sessions during the training. In contrast, the minimally supervised group received remote support from another certified professional in exercise sciences once a week via direct messaging (e.g., WhatsApp) (see Figure 1).

Measures

An assessor blinded to allocation gathered functional capacity measures (primary and secondary outcomes).

Descriptive Variables

Sex, age, education level, body weight, height, medical features, comorbidities, and the use of pharmaceuticals to treat diseases were self-reported by subjects through a virtual questionnaire platform.[19] The body mass index (BMI) was then calculated afterward. Global cognitive function was evaluated using the Montreal Cognitive Assessment (MoCA).[20] The presence of probable sarcopenia was screened by the SARC-F questionnaire.[21] We also assessed the subject's experience and familiarity with technological resources through a virtual questionnaire.

Primary Outcome: Functional Capacity

Muscle Endurance and Power: the 30-Second Chair Stand Test

The 30-second chair stand test was utilized to assess the muscle endurance and power of the lower limbs and to predict the risk of falls.[22] The test required a chair with a backrest and no armrests, as well as a stopwatch.[22] At the evaluator's signal, the participant must sit down and stand up from the chair as quickly as possible with arms crossed over the chest. The total number of repetitions performed in 30 seconds was considered to evaluate muscular endurance.[22] The application of the virtual mode of this test presented excellent reliability (ICC = 0.91 [95%CI 0.82 to 0.95]).[19]

The number of repetitions in the first 20 seconds of the 30-second chair stand test was inserted into an equation[23] to evaluate muscular power. Average Power (watts) = -504.845 + 10.793 (body weight in kg) + 21.603 (repetitions on the 20" 30-second chair stand test).[24] The virtual model application also showed excellent reliability (ICC = 0.98 [95%CI: 0.96 to 0.99]).[19]

Muscle Strength: the 5-Time-Sit-To-Stand Test

The 5-time-to-stand test consisted of performing five repetitions of sitting and rising from the chair. The time to complete these five repetitions was recorded, and their execution in a shorter time indicates better functional condition of the participant.[25] The intrarater ICC indicated excellent levels of reliability (0.93 [95%CI: 0.85 to 0.97]) for the test in virtual mode.[19]

Functional Muscle Fitness: the Sitting Rising Test

The Sitting and Rising Test measured the supports (hands and/or knees or even hands on knees or legs) the participant needed to sit and get up from the floor.[26] A zero grade was assigned if the participant could not sit or get up from the floor independently or if more than four supports were necessary to get up. From a maximum score of five points for sitting and five points for rising, one point was lost every time a support was used, and half a point was lost for any evident imbalance. In the end, the final points for sitting and rising were summed. The intrarater ICC indicated 0.90 (95% CI: 0.78 to 0.95) reliability for this test in the virtual mode.[19]

Secondary Outcomes

Cognitive Function

Cognitive function was assessed remotely via videoconference to measure processing speed, inhibitory control, and verbal fluency. The Trail Making Tests A and B were used to evaluate processing speed.[27] Both tests demonstrated moderate

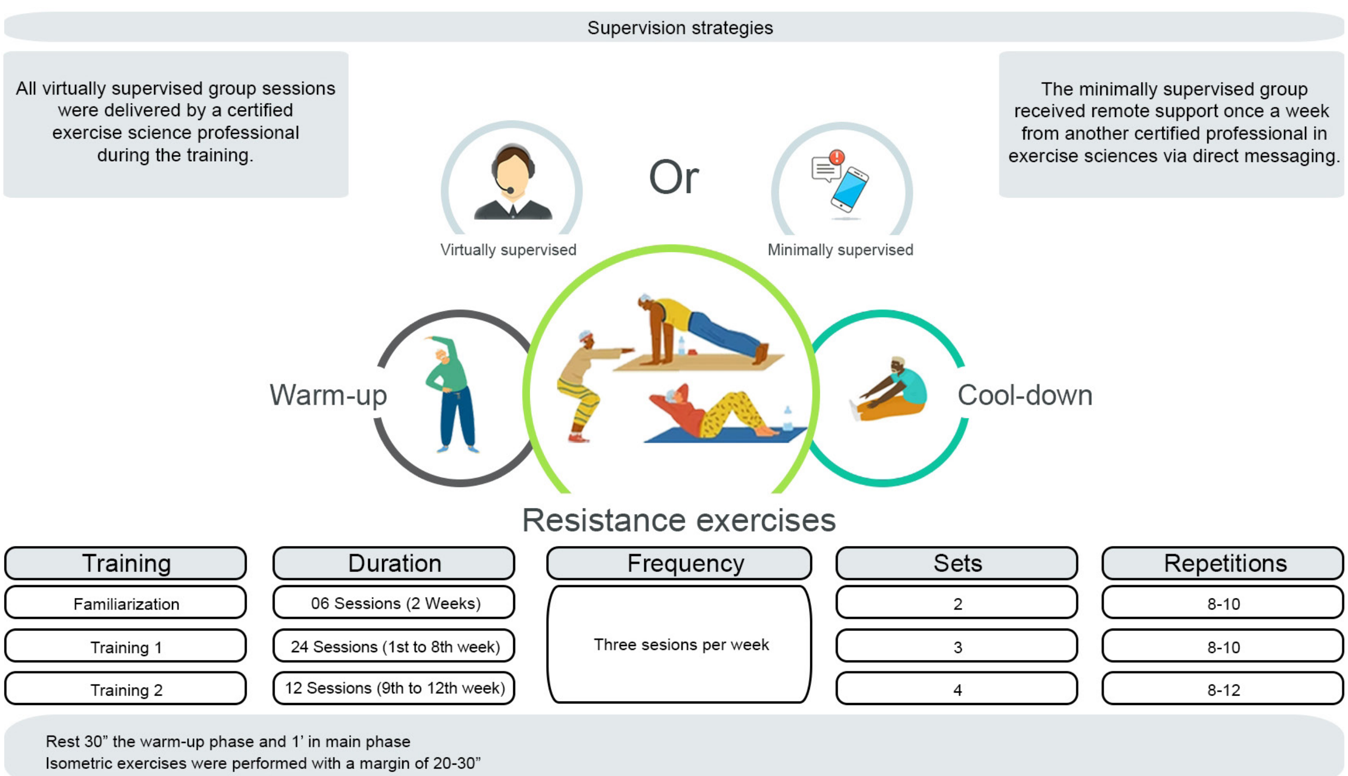

FIGURE 1. Supervision strategies

(ICC = 0.46, CI=95% -0.12 to 0.73) and good (ICC = 0.81, CI=95% 0.57 to 0.91) reliability, respectively.[19]

Inhibitory control was evaluated using the interference score of the Stroop test, which measures the number of hits in a maximum of 120 seconds minus the number of errors while considering the interference condition.[28] Three test conditions were used: naming colors, reading words, and the interference condition. Tests were administered using shared images. The Stroop test demonstrated excellent reliability (ICC = 0.87, CI=95% 0.74 to 0.94).[19]

Verbal fluency was evaluated using the Semantic Verbal Fluency of Animals test.[29] Participants were instructed to verbalize as many animal names with the letter "a" as possible within one minute. The test demonstrated high reliability (intrarater ICC = 0.91, CI=95% 0.80 to 0.96).[19]

Sample Size

The sample size was determined a priori using G*Power 3.1 software (https://www.psychologie.hhu.de/arbeitsgruppen/allgemeine-psychologie-und-arbeitspsychologie/gpower), which calculated a minimum of 34 participants as necessary. The inter- and intra-group interaction ANOVA was utilized to calculate sample size, with input parameters including an effect size of 0.25;[30] alpha of 0.05, power of 0.80, two groups, and two measurements. A standard correlation between measures of 0.50 and an attrition rate of 20% were also established. The use of an effect size of 0.25 was based on a previous meta-analysis which examined the effects of minimally supervised home physical training in healthy community-dwelling older adults, compared to an unsupervised model. The variable muscle strength was considered to establish the sample calculation.[30]

Statistical Analysis

The data were analyzed using IBM SPSS Statistics 25.0 (IBM SPSS Statistics, Armonk, NY). We utilized linear mixed models to determine the effects of virtually supervised exercise training compared to minimally supervised home-based exercise training on each outcome of interest. All analyses followed an intention-to-treat approach, with all randomized participants included in the analysis, irrespective of dropout or treatment adherence rate. The allocation group and time-point (baseline and follow-up) were established as fixed effects, and participants as random effects. Mixed models were constructed to determine the interaction term (group × time-point) (e.g., Virtually vs. Minimal Supervision), and a Dunn-Sidak post hoc test was employed when significance was observed.

Regarding the treatment effects on cognitive outcomes, we controlled for age, sex, and educational attainment in our analyses. Multiple imputations were used to handle any missing data issues. The main results are presented as estimated marginal means (95% CIs) and mean differences between groups. The significance level was set at $p < .05$ for all analyses.

RESULTS

Out of the 77 participants initially enrolled, 39 were excluded because they did not meet the inclusion criteria related to health issues (n=23) or did not agree to participate (n=16). Subsequently, 38 participants were deemed eligible, completed the baseline assessment, and were randomly assigned to one of the study arms (18 for the virtually supervised group [Group 1] and 20 for the minimally supervised home-based exercise training group [Group 2]). During follow-up, four participants withdrew from the study because of a lack of interest (n=3) or medical issues (n=1) that were not associated with the exercise programs (see Figure 2). Regarding the weekly training frequency, we observed a difference of approximately 25% between the groups. The virtually supervised group presented 60% adherence, while the minimally supervised group presented 83%. The sample consisted generally of older people with more than 12 years of schooling, with normal mental health and mood profile indicators classification. There was a discrepancy between groups regarding frequency rates (see Table 1). Table 1 presents the general characteristics of the experimental groups at baseline.

Table 2 shows estimated within-group changes and between-group differences at the end of a 12-week intervention and the results after 12 weeks. We did not observe significant within-group changes in any of the functional outcomes. Similar results were observed for cognitive outcomes, except for the Stroop test ($p = .03$), in which Group 2 performed better (-21%). There were no significant between-group differences in primary and secondary outcomes at the end of the 12-week intervention (see Table 2).

DISCUSSION

The study hypothesis considered that the group submitted to the program with virtual supervision would present better results than the minimally supervised group. This hypothesis was refuted, as no differences were observed between the groups. Furthermore, both groups did not show changes in outcomes over time, indicating that the HBE training programs could only maintain physical and cognitive status over the 12 weeks.

Regarding the primary outcomes, the present study did not find significant changes in strength, endurance, or muscular power at the e nd of the 12-week intervention. These findings initially appear to diverge from previous studies that have demonstrated that unsupervised and minimally supervised home resistance training can modestly improve balance and measures of leg strength and power (such as sitting and standing performance) compared to a group of control. However, several considerations need to be made and may partially explain this divergence. Firstly, previous studies have shown that resistance training at home modestly improves measures of lower limb muscle strength and power compared to control groups that only performed usual care.[8,10]

Another relevant aspect is that the older adults included in this study were functionally independent, had experience practicing resistance exercises, and had good physical performance at the beginning of the study. According to the law of diminishing returns,[31] the magnitude of exercise-related health benefits changes depending on the initial activity state, with small effect sizes expected on physical performance in highly functional individuals.[30] In other words, it is plausible that both exercise programs could not elicit an adequate adaptive response due to participants' high mobility status and experience with resistance training. Finally, there was no emphasis or specific recommendations for achieving muscular strength (overcoming resistance in the shortest possible time). The absence of muscular strength adaptations is in line with previous studies, which indicated that relevant gains in muscular power from a training regimen are related to the characteristics of the exercise protocol. Therefore, other studies examining the effects of HBE on functional outcomes should consider participants' functional status at baseline, and appropriately adapt exercise prescriptions to adhere as closely as possible to DeLorme's basic principles.[7]

Despite these results, it is worth highlighting that social isolation during the pandemic affected the physical and mental health of older people in the community.[3] Decreases of around 14% in lower limb muscle strength were observed.[3] Other important indices related to functional capacity also suffered declines, such as muscular power (-7%) and functional muscular fitness (-20%).[3] Although they did not improve physical function, the 12-week interventions (both protocols) results can be considered significant, as they seem to have guaranteed maintenance of levels of strength, endurance, and muscular power. It is essential to mention that lower limb muscle strength levels can predict functional mobility, adverse health-related outcomes, and premature death.[32]

Similar results were observed regarding cognitive outcomes. Although the literature demonstrates that different types of physical exercise,[33] specifically resistance training,[34] improve cognitive function, our study did not show a significant improvement in this outcome. It is worth noting that participants' global cognition scores at baseline were already close to the maximum, limiting the potential for improvement. Additionally, both groups exhibited similar cognitive performance at baseline, and the small changes during the intervention may not have been sufficient to differentiate the two groups. Another plausible explanation for our findings is that the length of our intervention was relatively short (12 weeks). The current

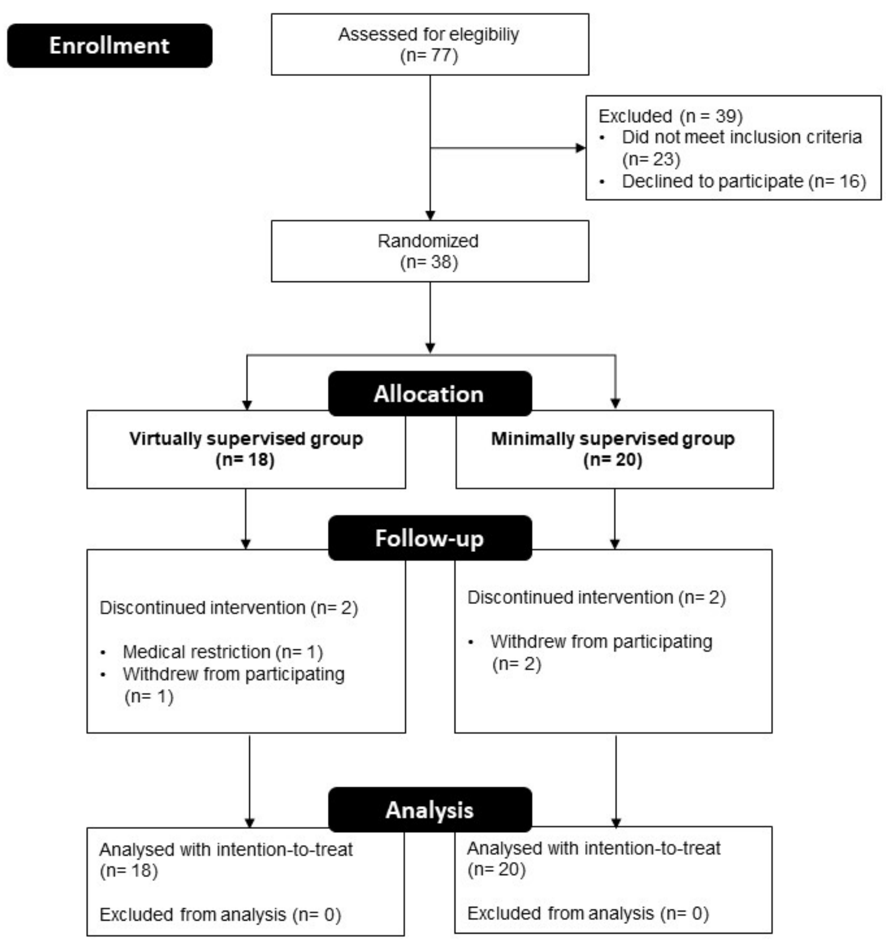

FIGURE 2. Study flowchart

TABLE 1.
General characteristics of the experimental groups at baseline

Variables	*Total sample (n= 38)*	*Virtually supervised group (n= 18)*	*Minimally supervised group (n= 20)*	*p*
Sex, n (% women)	31 (81.6)	15 (83.3)	16 (80.0)	.794
Age, average (SD), years[a]	68 (7)	68 (6)	69 (7)	.725
Body weight, average (SD), kg[a]	69.8 (12.2)	71.9 (10.5)	67.9 (13.5)	.286
Height, average (SD), m[a]	1.59 (0.06)	1.59 (0.07)	1.58 (0.06)	1.000
Body mass index, average (SD), kg/m²	27.8 (4.9)	28.5 (4.1)	27.2 (5.5)	.397
MoCA, average (SD), score[b]	23.08 (2.84)	23.17 (2.94)	23.00 (2.81)	.859
Risk of sarcopenia, average (SD), score[c]	1.38 (1.12)	1.56 (1.15)	1.10 (1.07)	.184
Education, n (%)				
≥12 years	36 (94.7)	17 (94.4)	19 (95.0)	.940
Health Conditions, n (%)				
Suffered falls in the last year	10 (26.3)	6 (33.3)	4 (20.0)	.358
Hypertensive	8 (21.1)	6 (33.3)	2 (10.0)	.082
Diabetics	2 (5.3)	1 (5.6)	1 (5.0)	.940
Musculoskeletal problems	11 (28.9)	8 (44.4)	3 (15.0)	.049*
Cardiac problems	3 (7.9)	1. (5.6)	2 (10.0)	.617
Use of medication for comorbidities	12 (31.6)	7 (38.9)	5 (25.0)	.364
Internet Environment and Technologies[a], n (%)				
Experience with video conferencing features	29 (76.3)	14 (77.8)	15 (75.0)	.843
Full familiarity with the Internet and technologies	12 (31.6)	6 (33.3)	6 (30.0)	.452
Daily use of the internet and technologies, but with difficulties	25 (6.8)	11 (61.1)	14 (70.0)	.972
No familiarity with the internet and technologies	1 (2.6)	1 (5.6)	0.0 (0.0)	.947

SD = standard deviation.
[a]Self-report data by participants.
[b]Data obtained by MoCA via video call ranging from 0 to 31 points (≤19 points indicates cognitive impairment).
[c]Data obtained by sarcopenia screening questionnaire (SARC-F); score ≥4 indicates a risk of sarcopenia.

literature suggests cognitive gains after long-term (e.g., interventions longer than six months) resistance exercise training.(35)

Finally, analyzing the results in a broader context, it is essential to mention that the virtually supervised group had a lower training frequency (approximately 25%) than the minimally supervised group. It is possible that the fixed days and times established between the participants in the virtually supervised group and the investigator influenced the lower frequency. Despite this, the observed results were similar in both groups, even with a smaller total volume or dose. These results are consistent with other findings showing that older adults respond better to supervised physical exercise.(9)

This study has several limitations that should be highlighted. Firstly, we did not monitor the presence of co-interventions over the 12 weeks, so participants may have engaged in other activities that could have influenced the exercise adaptations. Second, we could not assess participants' adherence to stay-at-home guidelines during the COVID-19 pandemic, which could have impacted the study outcomes. Third, the treatment protocol primarily involved weight-bearing exercises to promote balance and mobility, and limited access to specific equipment (e.g., elastic bands, free weights, etc.) made it difficult to adequately progress in terms of volume and intensity, potentially impacting the physical and cognitive adaptations observed. Fourth, the absence of a control group (e.g., usual care) precludes concluding treatment efficacy. Fifth, the sample size was relatively small, and the study was conducted at a single center, which may limit its generalizability.

Regarding functional aspects, it is essential to acknowledge that different tests may provide varying perspectives on physical function, even if the in-person assessment model is similar.(36) However, our study has several strengths. Remote guidance for a home-based training program may offer a promising solution to overcome the barriers to physical activity commonly encountered by older individuals, such as mobility limitations and lack of time.(12) Additionally, individual or group-based classes are not required for this protocol. Our results demonstrate that this approach is safe and feasible for older adults, although further studies are necessary to confirm these findings.

TABLE 2.
Estimated within-group changes and between-group differences at the end of a 12-week intervention

Outcomes	*GROUP 1 (n=18)*			*GROUP 2 (n=20)*			*GROUP 1 vs. GROUP 2 (Follow-up)*
	Baseline	*12 weeks*	*δ%*	*Baseline*	*12 weeks*	δ%	*Mean difference (CI 95%)*
Chair Stand Test (sec)	14.0 (5.5)	12.7 (3.3)	-9%	12.2 (4.4)	11.7 (3.5)	-4%	1 (-1.24; 3.24)
Mean change (CI95%)	1.3 (-1.77; 4.37)			0.5 (-2.05; 3.05)			
Chair Rise Test (repetitions)	11 (3.8)	12 (4.0)	14%	12 (2.7)	12 (4.2)	0%	0,2 (-2.51; 2.91)
Mean change (CI95%)	-1.6 (-4.24; 1.04)			0 (-2.26; 2.26)			
Chair Rise Test (watts)	438.0 (115.8)	432.1 (103.8)	-1%	407.7 (150.3)	391.0 (166.8)	-4%	41,1 (-51.53; 133.77)
Mean change (CI95%)	5,9 (-68.59; 80.39)			16.7 (-84.94; 118.34)			
Sitting Rising Test (score)	4 (3.2)	4 (3.7)	-2%	5 (3.1)	5 (2.9)	6%	-1 (-3.18; 1.18)
Mean change (CI95%)	0.1 (-2.24; 2.44)			-0.3 (-2.22; 1.62)			
Trails A (sec)	15.66 (1.8)	13.10 (1.8)	-16%	14.40 (1.7)	11.44 (1.7)	-21%	1,6 (-3.48; 6.79)
Mean change (CI95%)	-2.5 (-6.22; 1.10)			-2.9 (-6.43; 0.51)			
Trails B (sec)	72.92 (15.7)	92,03 (15,7)	26%	85.77 (14.9)	67.40 (14.9)	-21%	24,6 (-18.72; 67.99)
Mean change (CI95%)	19.1 (-19.03; 57.26)			-18.3 (-54.56; 17.82)			
Stroop Test (interference score)	20.11 (1.0)	21.19 (1.0)	5%	22.85 (0.9)	21.20 (0.9)	-7%	-0,0 (-2.77; 2.75)
Mean change (CI95%)	1.0 (-0.56; 2.72)			-1.6 (-3.20; -0.09)			
Animal naming (number of words)	3.79 (0.5)	4.53 (0.5)	20%	4.60 (0.5)	4.80 (0.5)	4%	-0.2 (-1.88; 1.34)
Mean change (CI95%)	0.7 (-0.32; 1.82)			0.2 (-0.82; 1.22)			

Values presented as mean (standard deviation); Group 1: virtually supervised group; Group 2: minimally supervised group; CI: confidence interval; *: significance; δ: percentage difference between the measurements of the variables in the pre and post moments

CONCLUSION

HBE training delivered with virtual or minimal supervision may provide maintenance of physical and cognitive functions in healthy and well-functioning community-dwelling older adults who experienced activity restrictions due to the COVID-19 pandemic in Brazil.

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CONFLICT OF INTEREST DISCLOSURES

We have read and understood the *Canadian Geriatrics Journal*'s policy on conflicts of interest disclosure and declare there are none.

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