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A virtually supervised exercise program improved fitness and mental wellness in healthy and comorbidity older adult individuals during the COVID-19 pandemic

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Background: The COVID-19 pandemic affected older adults worldwide. Sedentary older adults experienced more severe adverse health effects due to their shelter-in-place. Physical activity was strongly recommended during periods of social distancing. The present study evaluated the impact of a virtually supervised exercise program on the physical fitness and mental health of Mexican older adults during the pandemic's lockdown.

Methods: Participants were 44 older adults who were assigned to one of four physical fitness groups: a healthy control group (Ctrl-H, $n = 15$), a comorbidity control group (Ctrl-COM, $n = 9$), an exercise group without comorbidities (Exe-H, $n = 11$), and an exercise group with comorbidities (Exe-COM, $n = 9$). The participants engaged in a 60-min, virtually-supervised concurrent exercise session three times/week for 12 weeks. Fitness was measured using the online Senior Fitness Tests and the 4-m Gait Speed Test. Mental health was evaluated through virtual interviews using the Hamilton Depression Rating Scale, the Geriatric Depression Scale, and the Connor-Davidson Resilience Scale. Within-subject pre vs. post-intervention comparisons tested for significant differences, between-groups and over time.

Results: Significant interactions were found in the scores of the Geriatric Depression Scale ($p \leq 0.0001$; $\eta_p^2 = 0.35$), the Hamilton Depression Scale ($p \leq 0.0001$; $\eta_p^2 = 0.35$), resilience scores ($p \leq 0.0001$; $\eta_p^2 = 0.46$), lower-body strength ($p \leq 0.0001$; $\eta_p^2 = 0.32$), timed up-and-go test ($p = 0.018$; $\eta_p^2 = 0.18$), the 6MWT distance scores ($p \leq 0.0001$; $\eta_p^2 = 0.39$), and the 4-m gait speed test scores ($p = 0.011$; $\eta_p^2 = 0.20$).

Conclusion: A long-term virtually-supervised exercise program conducted during the COVID-19 lockdown period led to marked improvements in both the fitness and mental health of older Mexican adults. Comorbidities did not

diminish these benefits. These findings provide empirical support for online exercise programs in the daily routines of older adults to make clinically meaningful improvements in both physical and mental well-being.

KEYWORDS

older adults, physical exercise, wellness, fitness level, social distancing

Introduction

SARS-CoV-2 (Severe Acute Respiratory Syndrome Coronavirus-2) spread worldwide quickly (1–3), with more severe SARS-CoV-2 cases reported more frequently in older adults and people with chronic diseases (hypertension, type 2 diabetes, cardiovascular diseases, and comorbidity patients) (4).

COVID-19 was a whole-body infection that affected the brain, heart, insulin regulation, and other organs, thus exacerbating chronic disease (5, 6). Health systems around the world implemented preventive medicine strategies that included widespread shelter-in-place commands, quarantine, and limiting participation in outdoor activities, including sports, and exercise. Public gatherings and travel were severely curtailed. During that time, many public health officials highlighted that social distancing and isolation would also induce an inactive and sedentary behavior lifestyle, thus having deleterious downstream effects on physical fitness and mental health (2, 7, 8). Moreover, it is well known that the social distancing impact negatively on the life quality (including emotional health), in older adults with comorbidities (9, 10, 11), additionally authors have previously identified and suggested bidirectional association among diabetes, and cardiovascular diseases with mood disorders in adults and older adults (12, 13). On the other hand, in older adults, the sedentary behavior facilitates body weight gain, harms the function of the cardiovascular system, impairs the immune system responses, and increases the risk of suffering psychological and mental disorders (e.g., depression, psychological stress, and anxiety) and low resilience (14–16). Likewise, authors have previously identified that the sedentary behavior is a strong independent risk factor to suffer cardiovascular diseases in older adults with diabetes (17). The previous information emphasizes the need to practice physical activity in healthy and commorbidly older adults, this kind of intervention was widely recommended throughout social distancing (9, 18–23), the recommendations included practice aerobic exercise (e.g., walking) complemented by balance and strength exercises (21, 23). Despite the widespread implementation of these recommendations, there is scant empirical data on the long-term impact of PE sessions using virtual supervision.

The current study assessed the impact of a virtually-supervised exercise training program during COVID-19 quarantine. We collected outcomes data change in physical fitness and mental health in healthy Mexican older adult controls compared to matched patients with comorbidity chronic disease. We hypothesized that a home-based exercise program, supported by virtual supervision, would induce positive physical fitness and mental health outcomes in all individuals; however, older adults with comorbid chronic disease would benefit most.

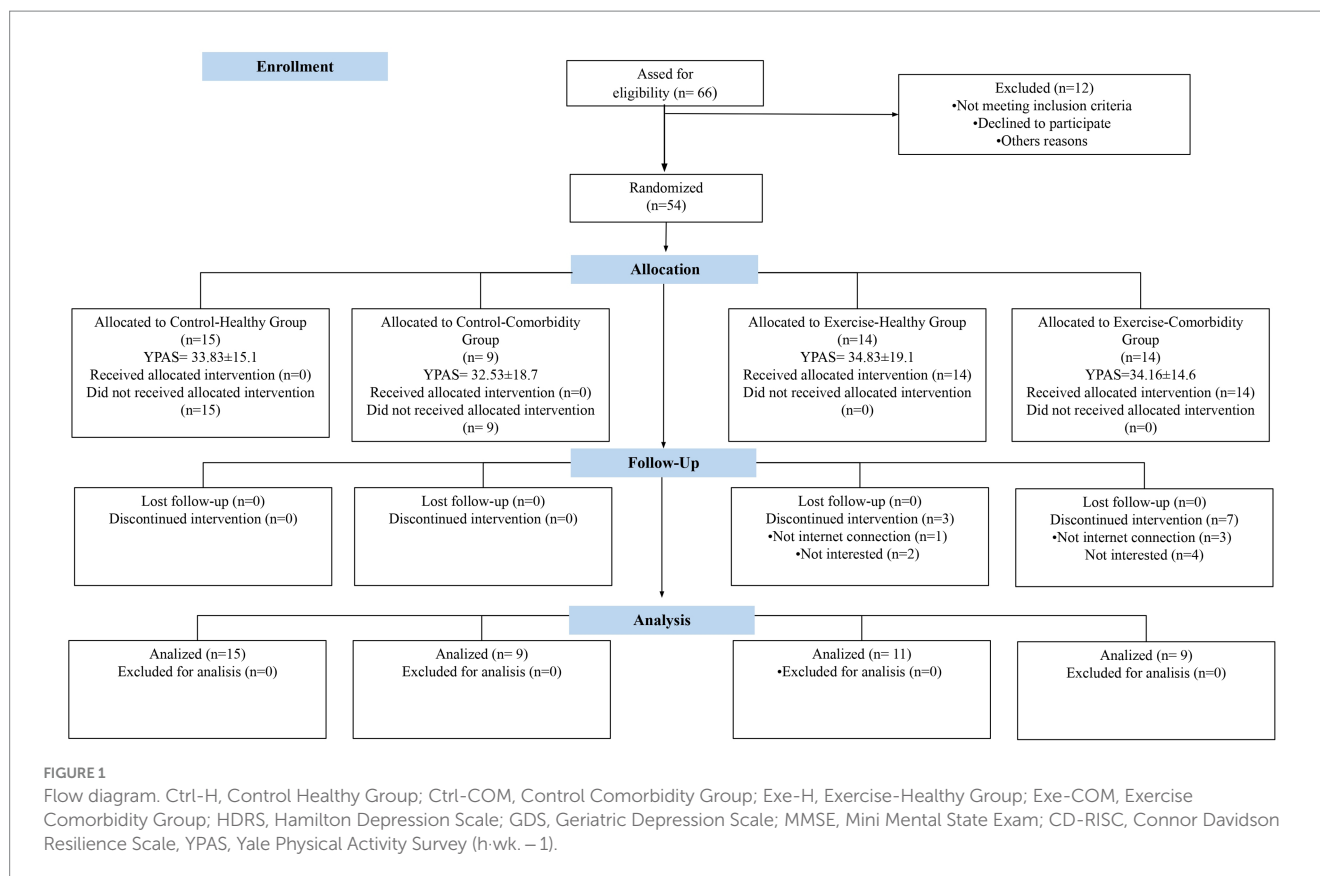
Methods

Study design and sample size

The current project followed a pragmatic clinical trial (non-random assignment) performed using virtual tools such as Facebook, WhatsApp, and Google Meet. The sample size comprised 44 older adults. First, the researchers advertised the project through a Facebook social media message. The interested people attended a video virtual meeting (Google Meet) to receive detailed information about the procedures and the aim of the study. Second, all interested individuals signed an informed consent (Google Forms). We assigned older adults to a *control group* (total sample = 24) subdivided into two groups: *Healthy control* (Ctrl-H, $n=15$) individuals with no reported disease, and a *Comorbidity control* (Ctrl-COM, $n=9$) group that included participants with self-reported hypertension, diabetes, or hypertension/diabetes. Both groups did not attend the training program; they were allowed to practice PE according to their lifestyle. Third, a *training group* (total sample = 20), included two groups: *Exercise-Healthy* (Exe-H, $n=11$) individuals (no self-reported comorbid disease) and *Exercise comorbidity* (Exe-COM, $n=9$) who reported hypertension, diabetes, or hypertension/diabetes. The exercise groups attended a combined concurrent exercise training program (12 weeks, three times per week) with virtual supervision. The study was completed between February and April 2021 and the protocol was approved by the Research Ethics Committee of the Facultad de Medicina y Psicología Campus Tijuana de la Universidad Autónoma de Baja California, México. The protocol was registered under the code 889/2020–2.

Cognitive testing, depression and resilience measurements

Questionnaire completion was supported by staff trained in Google Forms. The depression and anxiety symptom inventories completed by the individuals were the *Hamilton Depression Scale* of 17 items (HDRS) (24). The HDRS was previously identified as a tool with good internal consistency (Cronbach's $\alpha=0.789$) (25), and the *Geriatric Depression Scale* 15 items (GDS-15) (26, 27), the GDS is a valid method to assessing depressive symptoms in Hispanic and Latin American population, having cutoff of 4 to define a depressive condition in the individuals (28). The global cognition was assessed by the *Mini-Mental State Examination* [MMSE; Cronbach α for Mexican-American (Spanish Interview) = 0.83] (29). The HDRS, GDS, and MMSE are neuropsychological tools used in Mexican older adults (30). Finally, resilience was measured by the *Connor Davidson Resilience Scale* (CD-RISC) (31), an instrument used in the exercise



training intervention (32), and validated in Spanish language (Cronbach's $\alpha = 0.79$) (33, 34). The cut off score for CD-RISC has not been established yet, however, it is well known that a higher CD-RISC score reflects a high resilience level (31). Each questionnaire was supported by staff trained in Google Forms. During the questionnaire design, the researchers team made several trials about the hyperlink of neuropsychological testing, and answered those, checking if the collected information was saved in a particular database (Excel file). Once revised that hyperlink of neuropsychological testing, and the data base was correctly, the researchers shared the questionnaire to the participants who were supervised by trained staff using a synchronous virtual meeting strategy. The study's design is presented in Figure 1.

Physical fitness assessment

Remote assessments (through Google Meet) physical fitness was assessed with the *Senior Fitness Test* (SFT) (35), for this, we followed the methodology previously published for online testing (36–38). In brief, the webcam was positioned in front of each participant during the test. The SFT battery was demonstrated by a licensed instructor in practice, and the participants were asked to repeat the exercises. In order for the exercises to be perfectly performed, the corrections were performed by the instructor when necessary. The physical fitness tests were performed following this order:

The 30-s chair test consisted of performing the maximum number of standing movements for 30 s from and sitting in a

chair of 45 cm height approximately to measure lower-body strength. *The Curl Up Test*: Consisted in perform the maximum number of biceps curl-ups using a water bottle (2.25 kg for women and 2.0 kg for men) during 30 s to measure upper-body strength. *The 8-foot timed up-and-go Test* (TUG): was used to measure dynamic balance the participants were seated in a chair. A bottle of water was placed 2.44 m in front of the front edge of the chair. The participant walked as soon as possible through the bottle of water to get back to the chair and the time was recorded. *The timed 4-meter Gait Speed Test*: was recorded is a test considered a good measure of disability and a predictor of poor clinical outcomes in older adults, the static 4 meter test was performed in the backyard or front yard, or on the sidewalk to have the space necessary to perform (39, 40). To carry out the test, a flat route free of obstacles was identified, and 4 m were marked with adhesive tape. The participant stood with his toes touching the starting line. Subsequently standardized instructions were given: "walk to the line marked by the adhesive tape, walk in your usual gait speed and come to a sudden stop when yo have reached the cone ready ... start." Stopwatch timing began when the participant began to move. Timing stopped when the first participant's foot completely crossed the 4 m line (41, 42). Members of the research team (name's initials will be disclosed following peer review) supervised and trained staff using a synchronous virtual meeting strategy. Additionally, at the begin of the study, the Yale Physical Activity Survey (YPAS) was used to determine the physical activity levels in the participants. The YPAS is a questionnaire validated in Spanish language (43).

Exercise protocol

All virtual exercise sessions were supervised by researchers and trained staff through Google Meet video calls. Each session lasted 60 min and consisted of a warming-up (10 min), a main workout (40 min), and a cool-down (10 min). During warm-up, passive stretching, and mobility exercises were performed. The main workout included basic aerobic exercises such as walking inside the house twice (5 min walk and 1 min rest), five times high knees (30 s and 30-s rest), five times side steps (30 s and 30-s rest), and five times leg curl (30 s and 30-s rest).

The strength exercises involved a chair stand, biceps curls, one-arm row, and triceps extensions using water bottles (1–2L), wall push-ups, leg extensions, standing heel raises, standing kickbacks, and abdominal crunches. For the cool-down, passive stretching exercises were performed. All the exercises were performed at moderate intensity (i.e., *Borg's rating of perceived exertion Scale* from 6 to 20) where the participants had to reach an intensity between 12 and 14 points (44), for the last, the researchers made adjustment in the number of repetitions.

Statistical analysis

Descriptive statistics are presented as the mean and standard deviation ($M \pm SD$) unless otherwise noted. The intention-to-treat analysis approach was used in this study, given the drop-out of participants in the exercise groups (3 in the healthy and 7 in the comorbidity group). According to Little (45), we determined that missing data were generated completely at random (MCAR). Thus, we first used the mean imputation method, where the dependent variable of interest's arithmetic mean in the post-test scores recorded was imputed to the post-test participant's missing values (46). Then, we computed inferential statistics, including 4×2 mixed ANOVA tests (4 groups \times 2 measurements) for physical and cognitive variables. Third, we conducted a sensitivity analysis using the median imputation method to assess the robustness and reliability of the results. The *Least Difference Significant (LSD) post hoc* test followed significant ANOVA interactions, and the 95% confidence intervals (CI95%) for the mean differences are presented. Finally, the *effect size* (ES) was estimated by *partial* η_p^2 and *Cohen's d*. The η_p^2 ES was interpreted as *trivial* (0.01–0.059), *medium* (0.06–0.139), and *large* (≥ 0.14), and *Cohen's d* as *trivial* (< 0.2 –0.49), *medium* (0.5–0.75), and *large* (≥ 0.80) (47). The overall statistical significance was set *a priori* at $p < 0.05$. Statistical analyses were performed with the IBM-SPSS program (IBM Corp., Armonk, NY, United States), version 26.0.

Results

Baseline characteristics

Descriptive statistics for the participants using two methods of imputation for the intention-to-treat analysis are shown in Table 1. The sensitivity analysis is shown by using different imputation scenarios and ANOVA interactions to assess the robustness of results. ANOVA interaction p -values were similar in all but one variable (i.e., upper-body strength) when using the mean and the median imputation.

Psychological profile

No significant statistical group by measurements interaction was found in the Mini-Mental State Examination ($p = 0.162$; $\eta_p^2 = 0.10$). A statistically significant group by measurements interaction was found in the scores of the Geriatric Depression Scale–GDS score ($p \leq 0.0001$; $\eta_p^2 = 0.35$). Follow-up analysis showed a reduction in depression scores in the Exe-COM group ($p \leq 0.0001$, CI95% = -1.72 , -3.97 pts.), and the Exe-H group ($p \leq 0.0001$, CI95% = -2.14 , -3.98 pts.). There were significant mean differences in the post-test scores between the Ctrl-COM and the Exe-COM group ($p \leq 0.0001$, CI95% = 2.04 , 4.65 pts.), the Ctrl-COM, and the Exe-H group ($p \leq 0.0001$, CI95% = 1.46 , 3.87 pts.), the Ctrl-H and Exe-COM group ($p \leq 0.0001$, CI95% = 2.22 , 4.62 pts.), and the Ctrl-H and Exe-H group ($p \leq 0.0001$, CI95% = 1.77 , 3.83 pts.; Figure 2A). A statistically significant group by measurements interaction was found in the scores of the Hamilton Depression Scale ($p \leq 0.0001$; $\eta_p^2 = 0.35$). Follow-up analysis showed a reduction in depression scores in the Exe-H group ($p \leq 0.0001$, CI95% = -2.53 , -4.94 pts.). There were significant mean differences in the post-test scores between the Ctrl-COM and the Ctrl-H group ($p = 0.027$, CI95% = 0.31 , 4.72 pts.), Ctrl-COM and the Exe-COM group ($p = 0.001$, CI95% = 1.90 , 6.52 pts.), the Ctrl-COM and the Exe-H group ($p \leq 0.0001$, CI95% = 3.26 , 7.54 pts.), and the Ctrl-H and Exe-H group ($p = 0.003$, CI95% = 1.06 , 4.72 pts.; Figure 2B). A statistically significant group by measurements interaction was found in the resilience scores ($p \leq 0.0001$; $\eta_p^2 = 0.46$). Follow-up analysis showed an increased resilience in the Exe-COM group ($p \leq 0.0001$, CI95% = 2.49 , 6.75 pts.) and the Exe-H group ($p \leq 0.0001$, CI95% = 5.61 , 9.08 pts.). There were significant mean differences in the post-test scores between the Ctrl-COM and the Exe-COM group ($p \leq 0.0001$, CI95% = -4.32 , -9.91 pts.), the Ctrl-COM and the Exe-H group ($p \leq 0.0001$, CI95% = -5.37 , -10.54 pts.), the Ctrl-H and Exe-COM group ($p \leq 0.0001$, CI95% = -2.73 , -7.64 pts.), and the Ctrl-H and Exe-H group ($p \leq 0.0001$, CI95% = -3.81 , -8.24 pts.; Figure 2C).

Physical parameters

No significant statistical group by measurements interaction was found on upper-body strength ($p = 0.099$; $\eta_p^2 = 0.12$), trunk flexibility ($p = 0.454$, $\eta_p^2 = 0.05$), and arm flexibility ($p = 0.121$, $\eta_p^2 = 0.11$). A statistically significant group by measurements interaction was found on lower-body strength ($p \leq 0.0001$; $\eta_p^2 = 0.32$). Follow-up analysis showed an increase in lower-body strength only in the Exe-H group ($p \leq 0.0001$, CI95% = 1.90 , 5.08 reps.). There were significant mean differences in the post-test scores between the Ctrl-COM and the Exe-COM participants ($p = 0.005$, CI95% = -1.32 , -7.10 reps.), the Ctrl-COM and the Exe-H participants ($p \leq 0.0001$, CI95% = -3.48 , -8.83 reps.), the Ctrl-H and Exe-COM participants ($p = 0.020$, CI95% = -0.50 , -5.57 reps.), the Ctrl-H and Exe-H participants ($p \leq 0.0001$, CI95% = -2.69 , -7.27 reps.; Figure 3A).

A statistically significant group by measurements interaction was found on the timed up-and-go test ($p = 0.018$; $\eta_p^2 = 0.18$). Follow-up analysis showed a reduction in time in the comorbid control ($p = 0.047$, CI95% = -0.01 , -1.91 s) and Exe-H ($p = 0.030$, CI95% = -0.07 , -1.42 s) groups. There were significant mean differences in the post-test scores between the Ctrl-COM and the Exe-COM participants ($p = 0.031$, CI95% = 0.17 , 3.40 s), the Ctrl-COM and the Exe-H

TABLE 1 Descriptive statistics using two methods of imputation for the intention-to-treat analysis.

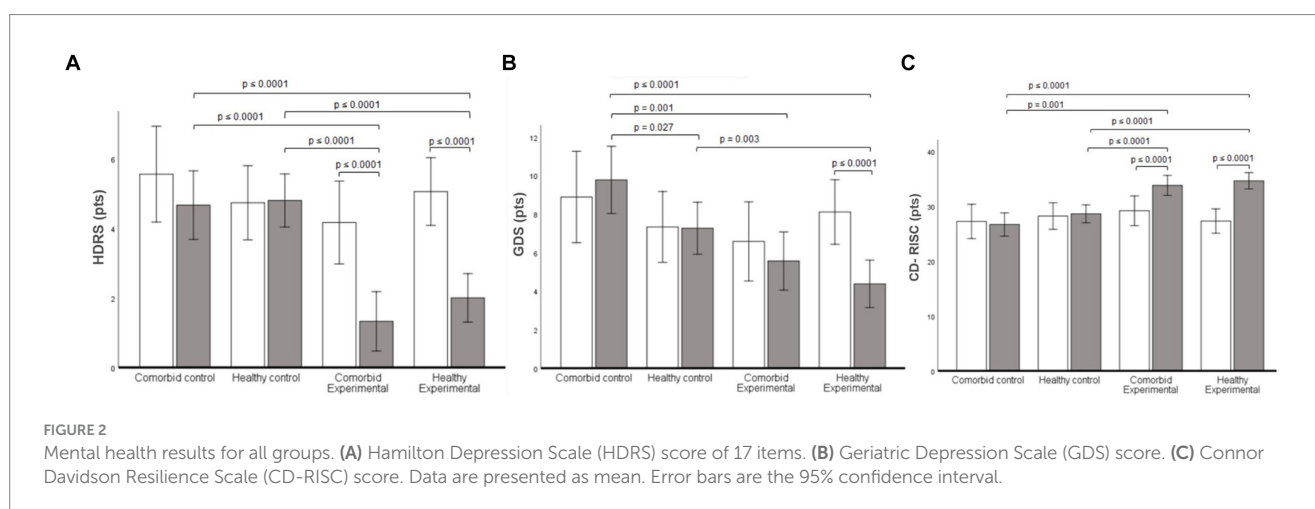
Group/variable	Imputation method							
	Pre-test	Post-test	Arithmetic mean imputation			Median imputation		
			AxB ($p \leq$)	A ($p \leq$)	B ($p \leq$)	AxB ($p \leq$)	A ($p \leq$)	B ($p \leq$)
Comorbid control ($n=9$)								
Lower-body strength (reps)	15.11 ± 4.37	13.22 ± 4.02	0.0001	0.979	0.011	0.0001	0.981	0.012
Upper-body strength (reps)	18.67 ± 3.87	21.11 ± 5.78	0.099	0.0001	0.521	0.036	0.0001	0.476
Trunk flexibility (cm)	-1.56 ± 1.24	-2.78 ± 3.03	0.454	0.934	0.035	0.280	0.662	0.023
Arm flexibility (cm)	-4.11 ± 5.30	-6.00 ± 5.83	0.121	0.085	0.008	0.154	0.115	0.011
Timed up-and-go (s)	7.10 ± 2.48	8.06 ± 2.65	0.018	0.572	0.019	0.012	0.661	0.016
6MWT (m)	634.33 ± 73.76	619.00 ± 67.97	0.0001	0.001	0.011	0.0001	0.001	0.011
4-m gait speed (s)	7.17 ± 1.51	7.28 ± 1.66	0.011	0.122	0.153	0.002	0.041	0.151
Geriatric depression scale (pts.)	5.56 ± 1.74	4.67 ± 1.58	0.0001	0.0001	0.001	0.0001	0.0001	0.001
Hamilton Depression Scale (pts.)	8.89 ± 3.82	9.78 ± 3.99	0.0001	0.008	0.043	0.0001	0.004	0.036
Resilience (pts.)	27.22 ± 5.22	26.67 ± 4.61	0.0001	0.0001	0.009	0.0001	0.0001	0.008
Healthy control ($n=15$)								
Lower-body strength (reps)	15.47 ± 4.55	14.40 ± 3.91						
Upper-body strength (reps)	17.67 ± 4.42	18.60 ± 3.18						
Trunk flexibility (cm)	-3.20 ± 3.78	-3.27 ± 3.62						
Arm flexibility (cm)	-2.60 ± 4.64	-0.67 ± 6.25						
Timed up-and-go (s)	7.98 ± 2.13	8.44 ± 2.33						
6MWT (m)	648.20 ± 42.18	620.53 ± 60.51						
4-m gait speed (s)	6.06 ± 1.11	6.57 ± 0.92						
Geriatric depression scale (pts.)	4.73 ± 1.53	4.80 ± 1.78						
Hamilton Depression Scale (pts.)	7.33 ± 1.76	7.27 ± 2.49						
Resilience (pts.)	28.20 ± 4.30	28.60 ± 3.78						
Comorbid experimental ($n=12$)								
Lower-body strength (reps)	17.92 ± 3.70	17.43 ± 2.63						
Upper-body strength (reps)	16.75 ± 3.91	20.32 ± 2.30						
Trunk flexibility (cm)	-1.25 ± 2.67	-0.43 ± 0.87						
Arm flexibility (cm)	-3.27 ± 6.51	-6.99 ± 6.73						
Timed up-and-go (s)	6.51 ± 1.31	6.28 ± 1.23						
6MWT (m)	649.42 ± 110.61	744.22 ± 38.90						
4-m gait speed (s)	6.38 ± 1.76	5.43 ± 1.68						
Geriatric depression scale (pts.)	4.17 ± 1.90	1.33 ± 1.13						
Hamilton Depression Scale (pts.)	6.58 ± 3.06	5.57 ± 1.91						
Resilience (pts.)	29.17 ± 4.73	33.78 ± 2.33						
Healthy experimental ($n=18$)								
Lower-body strength (reps)	15.89 ± 3.07	19.38 ± 2.57						
Upper-body strength (reps)	17.50 ± 3.50	18.47 ± 1.95						
Trunk flexibility (cm)	-2.00 ± 2.14	-1.38 ± 1.89						
Arm flexibility (cm)	-5.64 ± 4.49	-8.69 ± 5.01						
Timed up-and-go (s)	6.83 ± 1.91	6.09 ± 1.01						
6MWT (m)	641.00 ± 103.85	732.19 ± 49.92						
4-m gait speed (s)	7.02 ± 1.64	6.17 ± 1.52						

(Continued)

TABLE 1 (Continued)

Group/variable	Imputation method							
	Pre-test	Post-test	Arithmetic mean imputation			Median imputation		
			A×B ($p \leq$)	A ($p \leq$)	B ($p \leq$)	A×B ($p \leq$)	A ($p \leq$)	B ($p \leq$)
Geriatric depression scale (pts.)	5.06 ± 2.60	2.00 ± 1.33						
Hamilton Depression Scale (pts.)	8.11 ± 4.64	4.38 ± 2.23						
Resilience (pts.)	27.28 ± 4.66	34.62 ± 2.01						

ANOVA terms: AxB (Interaction between measurements and groups), A, Measurements (pre-test vs. post-test); B, Groups (Comorbid control, Healthy control, Comorbid experimental, Healthy experimental).



participants ($p=0.011$, $CI95\%=0.48, 3.47$ s), the Ctrl-H and Exe-COM participants ($p=0.004$, $CI95\%=0.74, 3.58$ s), and the Ctrl-H and Exe-H participants ($p=0.001$, $CI95\%=1.07, 3.63$ s; [Figure 3B](#)). A statistically significant group by measurement interaction was found on the 4-m gait speed test scores ($p=0.011$; $\eta_p^2=0.20$). Follow-up analysis showed faster speed times in the Exe-COM ($p=0.017$, $CI95\%=-0.18, -1.72$ s) and Exe-H ($p=0.009$, $CI95\%=-0.22, -1.48$ s) groups. There were significant mean differences in the post-test scores between the comorbid control and the Exe-COM participants ($p=0.005$, $CI95\%=0.57, 3.13$ s), and the Ctrl-H and Exe-COM participants ($p=0.047$, $CI95\%=0.02, 2.26$ s; [Figure 3C](#)).

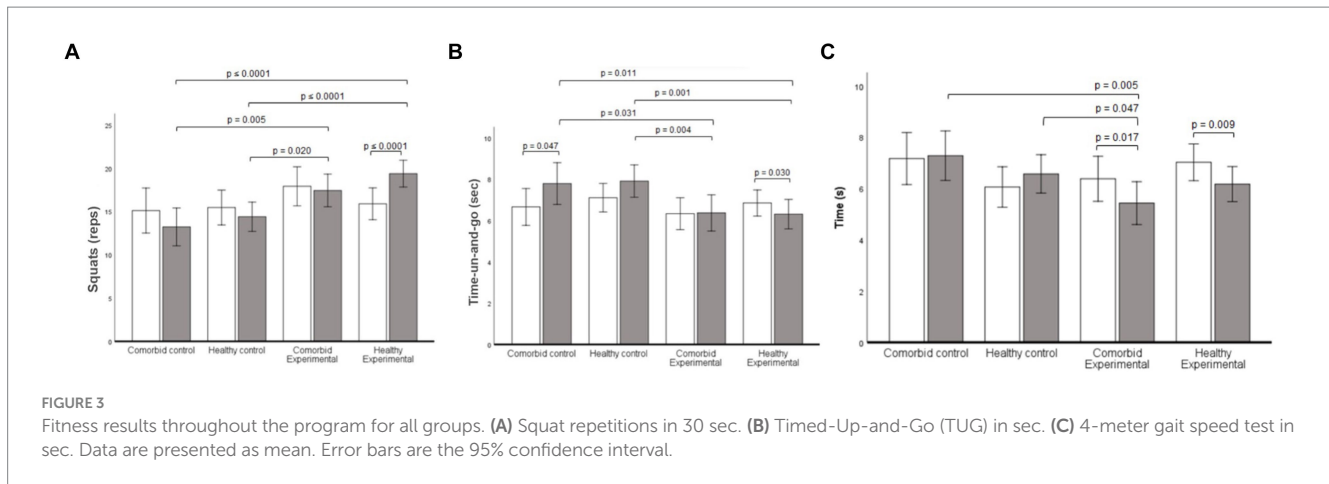
Discussion

The current study assessed the utility of a home-based training program to improve fitness and mental health in two groups of Mexican older adults (with and without comorbid conditions). Repeated measures of the SFT and depression symptom inventories indicated that 36 exercise sessions improved both fitness and well-being in older adults with comorbid conditions and those without. Our virtual exercise program increased the strength of the lower body, agility, and gait speed, and reduced depressive symptoms. A home-based exercise training with individual virtual supervision is a feasible intervention to reduce depressive symptoms and increase physical activity despite the pandemic's far-reaching shelter-in-place orders. These data converge with the substantial review articles and

perspectives about the recommendations to practice physical exercise during the COVID-19 lockdown to improve mental wellness (9).

Depression is prevalent in older adulthood (48, 49) and is a complex and persistent syndrome in old age (50, 51). A score above 4 points on the GDS instrument for Mexican older adults is considered the cut-off point to flag participants as potentially depressed (28, 30). In regard with it, the Exe-COM, and EXE-H groups showed a reduction in the GDS score, reporting lower than 4 (no depressive symptoms), additionally, the EXE-H showed in the $HDRS_{17}$ a reduction of 4 points, considering it a modest but clinically meaningful (52), those data indicate that the exercise performed at home reduces significantly the depressive symptoms in older adults, a response that was more consistently observed in EXE-H group. Salguero et al. (48) reported similar results where depressive symptoms were reported significantly less often in more physically active participants. That was true for both community-dwelling and older adults in assisted living. The finding converges with many other studies that show that virtual supervised exercise programs reduce depression (32). Notably, we could not measure neurobiological mechanisms of the improvement of depressive symptoms as a function of increased PE. Low circulating BDNF is linked to increased depressive symptoms in older adults, especially those with low activity levels and clinical conditions (53). Further, elevated PE is associated with increased circulating BDNF levels (53–55); however, the association is not well-established, and future studies should focus on measuring BDNF signaling.

Resilience, defined as the ability to successfully respond to acute stress, trauma, or adversities (56–58), was also enhanced by our exercise



program, regardless of health status (Figure 2C). Resilience is another complex index of mental health (57, 59) that involves the hypothalamic–pituitary–adrenal (HPA) axis activity. In highly-stressed individuals (i.e., low-resilience), HPA activity is significantly higher than in people who report moderate low stress (56). Chronic over-activation of HPA suppresses the immune system (60), leaving individuals more susceptible to chronic disease. Moreover, there is a consistent association between low resilience levels and a high prevalence of mental disorders of all types (58). Our results are compelling and important because simple exercise virtual exercise regimens could be an easy-to-implement and effective treatment to improve resilience levels in older adults who need the most help (15, 32, 61). Further, this repeated measures experimental design was stronger than the cross-sectional reports in the literature currently (15, 61, 62).

In the present study, lower-body strength was improved by the supervised exercise program, regardless of health status (Table 1). In older adults, leg muscle mass (22) and chair stand (36) improve following a remote virtually-supervised exercise program. Better lower-limb strength reduces fall risk (35) and preserves functional autonomy (22, 63). Thus, morphological adaptations elicited by the training sessions could explain the increased lower-body strength, especially the increased muscle mass (64) and hypertrophic responses (65). Concurrent training induces neuromuscular adaptations to improve muscle quality, resulting in significant improvements in the rate of force production (66). Convergent with this, chair stand test data, gait speed, and the TUG test also improved significantly after the exercise intervention. The gait speed has been previously considered a the “sixth vital sign” (39), this variable was identified as one independent risk factor for disability, cognitive impairment, falls, and depression (67, 68), consequently, authors have mentioned that a slow gait speed reflect micro-cerebrovascular disease, pathology of both cochlear and vestibular sense organs, white matter hyperintensities (WMHs) particularly involving the frontal lobe, and peripheral neuropathy (67–69). The previous data emphasize the usefulness of virtual exercise training aimed at improving the lower-body variables associated with functional autonomy, and potentially the preservation of the functions at specific brain functions in older adults, one adaptations that was not attenuated by chronic diseases such as hypertension and type 2 diabetes.

Despite promising findings linked with the functional autonomy, the current study has some limitations; first, we acknowledge that our

sample size was small, and the participants’ sex was uneven among groups. Sex is a relevant factor in response to exercise training (70, 71) and could have been controlled for in exercise assignments instead of *post hoc* statistical controls that were used. Second, the remote approach used in this work, did not provide other specific information about the potential morphophysiological adaptations (body composition analysis, surface electromyography, and so on). to induce better physical performance in the lower body. Third, metabolic variables were not collected, which prevented us from identifying if biological variables like blood glucose levels, diabetes, blood pressure, and circulating BDNF were also changing with physical fitness and self-reported mental health after a remote supervised exercise program.

Conclusion

The present study demonstrated that virtual home-based individual supervised physical activity is an effective strategy to improve fitness (lower-body strength), and mental wellness in older individuals with or without comorbidities. Supervised online physical activity tailored for older adults is a convenient and effective strategy that induces clinically meaningful change in fitness and mental health. By replacing standard exercise equipment with items commonly found at home, we were able to implement an exercise program for the homebound.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by Research Ethics Committee of the Facultad de Medicina y Psicología Campus Tijuana de la Universidad Autónoma de Baja California, México, the protocol was registered under the code 889/2020–2. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed

consent to participate in this study. Written informed consent was obtained from the individual(s) for the publication of any potentially identifiable images or data included in this article.

Author contributions

EC-M: Conceptualization, Writing – original draft. IR: Methodology, Writing – original draft, Writing – review & editing, Conceptualization. JM-P: Methodology, Writing – original draft. RR: Methodology, Writing – original draft. JM-J: Data curation, Formal analysis, Writing – review & editing. DJ: Data curation, Formal analysis, Methodology, Writing – review & editing. OG: Formal analysis, Writing – review & editing. AV: Data curation, Writing – review & editing. AJ-M: Conceptualization, Formal analysis, Funding acquisition, Methodology, Resources, Writing – original draft, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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