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Original Research

A Pilot, Virtual Exercise Intervention Improves Health and Fitness during the COVID-19 Pandemic

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ABSTRACT

International Journal of Exercise Science 15(7): 1395-1417, 2022. Physical activity levels are low in individuals with chronic disease (e.g., obesity) and have worsened during the COVID-19 pandemic. Purpose: Our pilot study tested a virtual exercise intervention for rural-dwelling adults with chronic disease from January-April 2021 for changes in mental health, physical fitness, and physical activity and for intervention fidelity. Methods: Participants (n = 8 [7 female]; age = 57.5 ± 13.8 years, body mass index = 38.2 ± 8.0 kg/m^2) completed an exercise intervention led virtually by collegiate health science majors. Participants attended two 60-minute sessions/week for 12 weeks, completing individually-tailored and progressed aerobic and muscle-strengthening training. A non-randomized control group matched on gender and age continued normal activity during the 12 weeks. Changes in mental health, physical fitness, and physical activity measures were evaluated using a 2x2 (group x time) analysis of covariance. Results: Both groups improved mental health, but only intervention participants lost weight (3.1 ± 1.0 kg; no change in controls). Step test, arm curls, and chair stands improved by 16.1-20.6% in the intervention and 7.8-12.1% in the control groups. Intervention participants did not increase overall physical activity during or after the intervention. Intervention fidelity was high; participants attended ~73% of sessions and rated the sessions 4.7 ± 0.6 (out of 5). Researcher observations rated exercise sessions as meeting 12.7 ± 0.6 of 16 goals. Conclusions: Our virtual exercise program was associated with positive mental health and physical fitness changes. Such programs may provide a method, even beyond the pandemic, to improve fitness in adults with chronic disease.

KEY WORDS: Quarantine, lockdown, Coronavirus

INTRODUCTION

Participation in physical activity (movement that increases energy expenditure above resting levels) and exercise (planned, purposeful physical activity) is known to promote health and physical fitness across all age groups, in healthy populations, and in those with chronic disease (e.g., obesity, diabetes, cardiovascular disease) (43). However, many adults in the United States do not meet the 2018 Physical Activity Guidelines (43) with ~52% of adults meeting aerobic guidelines, ~35% meeting muscle-strengthening guidelines, and ~23% meeting both when assessed via self-report. Notably, adults having one or more chronic diseases are more vulnerable to declines in mental health and physical fitness and are less likely to meet physical activity guidelines (6, 49). Commonly cited reasons for low physical activity participation include lack of time, lack of access to equipment or facilities to be active, and lack of knowledge regarding safe and effective physical activity participation (49). Addressing these issues may therefore increase physical activity participation in adults with chronic disease.

In late 2019 and early 2020, much of the world went into quarantine and/or lockdown due to the COVID-19 pandemic. In the years since the beginning of the pandemic, life has not returned to normal for many adults. Recent research has demonstrated decreased physical activity levels as well as significant negative effects of the pandemic on physical fitness, especially in adults with chronic disease (11, 30, 55). Weight gain and poor mental health due to decreased physical activity and altered eating behaviors have also been demonstrated (11, 32, 40), with one study showing that inactive individuals had poorer wellbeing and were less beneficially affected by policies aimed to promote wellness (33). Older adults appear especially susceptible to negative mental health and physical fitness effects if not active during the pandemic (5). Additionally, those who rely on facilities for structured exercise, such as those undergoing cardiac rehabilitation or who need supervision, experienced large decreases in physical activity during the pandemic (30, 55). Therefore, interventions targeting exercise participation, especially in these vulnerable populations, are needed.

While recommendations exist for exercising safely during the pandemic (21), less research has assessed effects on mental health or physical fitness, or fidelity (e.g., adherence, acceptability) of during-pandemic exercise interventions. A recent review provided mixed results as to the efficacy of online exercise interventions for adults with chronic disease pre-pandemic (3), but encouragingly one study found evidence of similar exercise adherence following in-person and virtual exercise interventions in adults with chronic disease (26). Additionally, recent studies using remote exercise training for patients with obesity and cardiovascular disease have reported improvements in aerobic fitness (i.e., VO_2max) and other fitness indicators, (i.e., body composition), sometimes on par with programs offered in-person (1, 18, 39). Indeed, recent studies have suggested that virtual rehabilitation will likely persist beyond the pandemic due to rehabilitation effectiveness coupled with noted benefits in terms of accessibility to those who cannot easily travel to an in-person site for rehabilitation (31, 38, 48, 53). Still, most such studies note the need for more research, as a move to virtual exercise training would represent a marked shift from conventional practices.

Given the relative newness of virtual exercise programming and the limited evidence as to the effectiveness and fidelity of virtual exercise interventions during the pandemic, this pilot study had several purposes. First, we sought to determine within- and between-group changes in mental health, physical fitness, and physical activity due to participation in a virtual exercise program in adults with chronic disease during a period of COVID-19 lockdown measures in January-April 2021. Second, we assessed intervention fidelity, which included participant adherence (percentage of sessions attended), self-reported exercise session acceptability (post-exercise survey), and researcher-determined session quality (number of session goals achieved). We hypothesized that intervention participants would make improvements in mental health, physical fitness, and physical activity following completion of the intervention and that the intervention would have strong adherence and high acceptability and quality.

METHODS

Participants

Participants were recruited via informational fliers posted at local primary care physician offices in Gratiot County, MI. Gratiot County is rural (population ~41,000, population density ~75 persons/mile^2) and relatively ethnically homogenous (~91% white). Median household income (~$47,000/year) and poverty levels (~15%) are worse than Michigan (~$57,000 and 13%, respectively) and United States averages (~$68,000 and 10%, respectively) (54). The need for access to exercise in this community was recognized by the local health department, who worked in collaboration with the authors' academic institution to develop a targeted exercise intervention through a community-engaged approach (25).

To be eligible for this intervention, participants needed to be at least 18 years of age and have physician clearance to engage in moderate- or vigorous-intensity exercise, a working email address, and access to internet and an electronic device (i.e., phone, computer) equipped with audio and video functions. Finally, participants had to be diagnosed with one or more chronic diseases. If participants had COVID-19, they were not allowed to participate until at least 2 weeks following diagnosis and with full alleviation of symptoms.

Recruitment for the intervention (Figure 1) included 53 potential participants, of whom eight completed the program. A non-random group of control participants was recruited for comparison and to address potential COVID-related quarantine or seasonal effects. Controls were matched 1:1 with intervention participants based on gender (7 female, 1 male in each group) and age (57.5 ± 13.8 years in intervention group, 53.0 ± 11.6 years in control group, p = 0.49) but not on body mass index (38.2 ± 8.0 kg/m^2 in intervention group, 29.2 ± 5.3 kg/m^2 in control group; p = 0.019). Participants in the intervention group had the following chronic diseases: obesity (87.5%), hypertension (62.5%), depression (50%), asthma/chronic obstructive pulmonary disease (37.5%), diabetes (25%), remission from cancer (25%), and heart disease (25%). Participants in the control group had the following chronic diseases: obesity (62.5%), depression (50%), heart disease (37.5%), hypertension (25%), diabetes (12.5%), and asthma/chronic obstructive pulmonary disease (12.5%). Given the nature of the intervention, it was not possible to blind participants to the group they were assigned.

All participants were provided with and signed written informed consent, and this study's methods were approved by the Alma College Institutional Review Board (IRB #R_0PaxK7xpjrIBUpb) and were performed in accordance with the Declaration of Helsinki. Additionally, this study followed CONSORT reporting guidelines for pilot studies (16). This research was carried out fully in accordance to the ethical standards of the International Journal of Exercise Science (36).

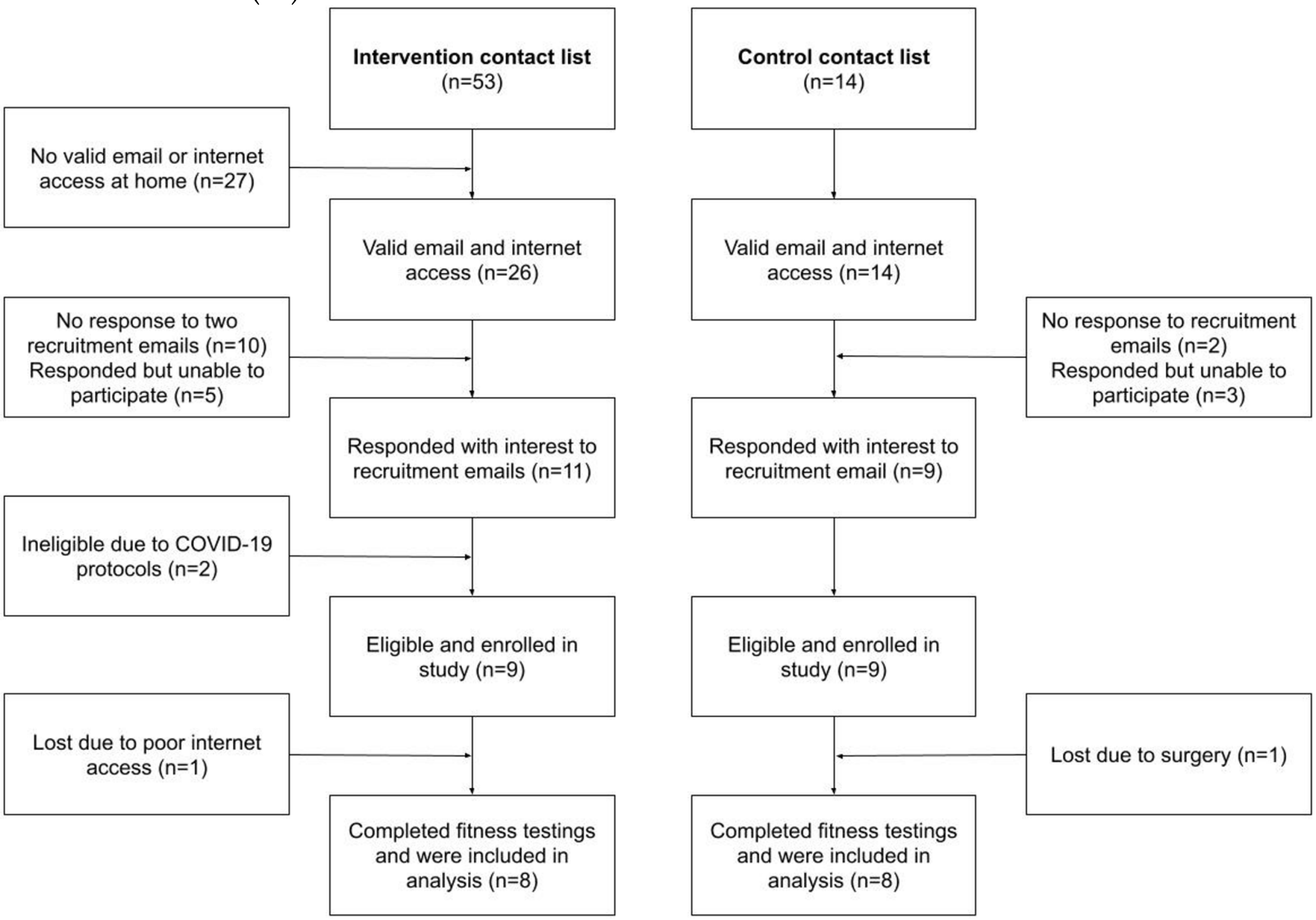

Figure 1. Participant recruitment flowchart.

Protocol

COVID-19 quarantine, stay-home orders, and recreation facility closures in the local community necessitated that our intervention be entirely virtual. Therefore, upon study enrollment, intervention participants were provided with resistance bands (Theraband, Akron, OH, USA) 1.4-4.5 kg free-weight dumbbells (VTX fitness, Houston, TX, USA), and a yoga mat (Sunshine Yoga, Monroe, NC, USA). Additionally, for all participants, soft ~1.5 meter measuring tapes (Muzhi, Beijing, China), 0.3 meter rulers (School Smart, Greenville, WI, USA), and a body-weight scale (Tanita Innerscan, Tanita Corp, Tokyo, Japan) were provided for the completion of baseline and post-intervention testing. These were delivered to participants in a contact-free manner where researchers dropped off equipment to an address indicated by participants. Participants were also instructed on how to download a video conferencing software (Microsoft Teams, Microsoft Corp., Redmond, WA, USA) onto an electronic device (e.g., laptop, smartphone, tablet) for use during the live exercise programming and fitness testing. A flowchart of the study protocol can be found in Figure 2.

Intervention: Following baseline testing, the control group was asked to continue their normal lifestyle behaviors (as if they were not enrolled in a research study) for the next 12 weeks. No restrictions were placed on activities that could be performed.

The intervention group completed a 12-week exercise intervention of two, 60-minute virtual exercise sessions per week in groups of 2-4 participants with two trained student exercise leaders. Participants were grouped together based on their goals, schedule availability, and fitness level as determined during baseline testing. Exercise leaders were collegiate junior or senior health science majors who had taken classes in fitness assessment and exercise prescription, underwent an additional 4-week training on exercise session development, and completed 4-6 weeks of pilot exercise training to ensure proficiency for administering the exercise sessions. For each session participants attended, they received an entry into a weekly drawing for a $10 gift card to a local grocery store.

The exercise sessions included a 5-10 minute warm-up and a 5-10 minute cool-down (including low-intensity movements such as walking in place, calisthenics, and flexibility exercises) and 40-50 minutes for conditioning split between aerobic and muscle-strengthening exercises. The exact workout composition (exercise types and durations, number of sets and repetitions, rest times) was tailored to participant goals and needs. However, at least 10 minutes had to be spent engaging in aerobic exercise and at least 10 minutes in muscle-strengthening exercises so that the entire conditioning phase was not spent in only one exercise type. In some cases, flexibility or neuromotor exercises (activities that incorporate motor skills including balance, gait, etc.) were added when appropriate.

Aerobic exercises included outdoor walking (weather pending), walking in place, “high knees”, side steps/lunges, regular or modified jumping jacks, and other exercises commonly used in group-conditioning classes. Outdoor walking was performed in one set for the desired aerobic exercise duration, and other exercises were performed in 15-180 second increments for 1-5 sets. Muscle-strengthening exercises included lower body (e.g., squats, lunges, calf raises, side/front/back leg raises from a standing position), upper body (e.g., biceps curls, wall push-ups, band pull aparts, military press, I Y T side-front raises) and core (e.g., supine leg lifts, crunches, prone leg lifts, “supermans”) exercises, performed for 8-15 repetitions/set and 1-3 sets. Rest times between exercises were at least 60 seconds, unless multiple exercises were performed in sequence as super sets or circuits, where the rest time for one exercise was used to perform another exercise using different muscle groups. Exercise prescriptions started at a light intensity; exercise leaders were instructed to engage participants periodically (e.g., every 5 minutes) to assess exercise intensity using the Talk Test (42) and to keep participants at a level where they could talk comfortably.

Exercise prescriptions were adjusted every ~2 weeks following American College of Sports Medicine guidelines on safe and effective exercise progression (20, 56). Aerobic exercise progression initially included increasing duration (by no more than 10% per week) or the number of exercises performed (by no more than one additional exercise per week). Muscle-strengthening exercise progression occurred when participants could easily complete 12 or more repetitions of a given exercise. Early progression involved increasing the number of sets (most often from 2 to 3), increasing the number of exercises targeting a given muscle group (most often adding in a second exercise targeting the specific muscle group), and/or decreasing the rest interval between sets. After ~4 weeks, the intensity of the aerobic and/or muscle-strengthening exercises was increased for exercises as tolerated. For illustrative purposes, an example exercise prescription for weeks 1 and 12 of the intervention can be seen in Table 1.

The intervention design was based loosely on tenets of Self-Determination Theory (51). Participants were asked to develop goals (and reevaluate them throughout the program) and identify times of the day/week in which they were most likely to want to exercise. In this way, participants had autonomy over the timing and focus of the exercise sessions. The intervention also sought to instill competence in participants through oversight, demonstration, and positive reinforcement. Exercise leaders placed emphasis on demonstrating exercises to participants and then giving feedback to ensure proper form on the exercises. Participants could therefore develop competence that they were doing exercises correctly and effectively. Third, we used a small-group setting with individuals of similar fitness levels and/or goals to encourage relatedness. In this way, participants could encourage each other, hold each other accountable for attending and completing sessions, and celebrate successes throughout the intervention.

Baseline testing: At baseline (January 2021), all participants joined a 1-on-1 video meeting with the research staff to self-report their age and height, and complete the mental health measures and physical fitness tests.

Mental health measures: Participants completed three online mental health questionnaires. The first was the Short Warwick-Edinburgh Mental Well-being Scale (NEF) general mental wellbeing measure (46). The NEF is a 7-question survey with five possible responses, which we numbered 1-5 and summed to get a score ranging from 5-35 (higher scores indicating better wellbeing). The Office for National Statistics' Measuring National Well-being scale (ONS) general mental wellbeing measure is a 4-question survey with 11 possible responses, summed to get a score from 0-40 (higher scores indicating better wellbeing) (37). Finally, the Patient Health Questionnaire on depression [PHQ-9]) is a 9-question survey with four possible responses, which we numbered 1-4 and summed to get a score ranging from 9-36 (higher scores indicating more symptoms suggestive of depression) (29). Each of these surveys has been validated in adult or older adult clinical populations (29, 41, 50).

Physical fitness tests: Participants self-measured body weight while in light clothing using a digital scale, followed by measuring waist (narrowest portion of torso between umbilicus and lowest ribs) and hip (widest part around gluteal musculature) circumferences using a measuring tape. Afterward, participants completed the Senior Fitness Test, a validated physical fitness testing battery (45). The battery consists of the 2-minute step test to assess cardiorespiratory endurance and/or functional capacity, the 30-second arm curl and 30-second chair stand test to assess upper- and lower-body muscular endurance respectively, the timed up-and-go (TUG) test to assess balance/agility, and the back scratch and sit-and-reach tests to assess upper- and lower-body flexibility. Between tests, participants were allowed to rest or consume water. All tests were monitored by research staff, who verbally explained the testing and proper setup of any necessary equipment, made corrections when necessary during the tests, timed the tests, and counted steps/repetitions.

For the 2-minute step test, participants began in standing position and lifted the foot of one leg vertically (until the knee of the lifted leg reached half the vertical distance between the knee and hip of the leg still on the ground) before setting the lifted foot on the ground and repeating the process with the other foot. This was done as many times as possible in the two minutes. For the 30-second arm curl test, participants sat upright in a chair while holding a dumbbell (2.3 kg for females, 3.6 kg for males) in their dominant hand. Once a timer was started, participants completed as many biceps curls as possible during the 30 seconds. This test was then repeated with the non-dominant hand, with the score from the arm with the most repetitions used for analysis. For the 30-second chair stand test, participants did body-weight squats by starting seated upright in a chair and then moving to a standing position before returning to seated position, completing as many as possible in 30 seconds. For the TUG test, participants placed a chair in an open area free of obstructions and measured out a 2.5-meter straight line, marking it with an object such as a cone. Then, participants sat in the chair; once a timer was started, participants stood and walked as quickly as possible to the cone/object, circling it and returning to the chair and sitting down. For sit-and-reach, participants sat in a chair, straightening one leg and bending forward while reaching toward the foot of the straightened leg while holding a 0.3 m ruler; the distance between the fingers and toe of the straightened leg was recorded (negative distance if fingers did not reach toes, and positive numbers if fingers reached past toes). Three trials were performed with each leg, and best trial from the leg with the best score used for analysis. For the back scratch test, participants raised one arm over their shoulder and down their back with elbow bent and holding a soft measuring tape, and the other hand up their back with elbow bent, trying to move the fingers of the two hands toward each other. The distance between the fingers of the two hands (negative distance if fingers of two hands did not reach each other, and positive numbers if fingers reached past each other). Three trials were performed with each arm, and the best score from the most flexible arm was used for analysis.

Physical activity assessment: To assess overall physical activity levels and the amount of time participants spent in different physical activity intensities, participants wore an ActiGraph GT9X Link accelerometer (ActiGraph Corp., Pensacola, FL, USA), the most commonly used accelerometer for physical activity interventions (35), for 7 days prior to the 1-on-1 baseline meeting. Before use, accelerometers were initialized with ActiLife version 6.13 (ActiGraph Corp., Pensacola, FL, USA). Participants were asked to continue normal activity during that week and wear the accelerometer for all waking hours on the dorsal aspect of the non-dominant wrist, secured with a manufacturer-provided wrist strap. The accelerometer sampled data at 30 Hz, starting at 6am on the day of monitor drop-off. Following accelerometer return, step and vector magnitude data were downloaded (with low frequency extension disabled) in 60-second epochs (27). The Choi algorithm was used to determine non-wear and has been validated in past research (8, 28), and participants had to have at least 3 days with at least 10 hours where the monitor was worn to have their accelerometer data included in the analysis (15, 22). Steps/day and vector magnitude counts/day were determined automatically from the ActiLife software, and the Montoye 2020 wrist-specific cut-points for adult populations applied to the 60-second epoch, vector magnitude data were used to determine the number of minutes/day spent in sedentary, light-, and moderate- to vigorous-intensity (MVPA) activities (34).

In the 1st and 12th weeks of the intervention, intervention participants were again given the ActiGraph accelerometer to wear for one week so that change in activity levels from before the intervention to during the intervention could be assessed. The same placement, initialization, and analytic procedures were used for the accelerometer data as in the baseline testing.

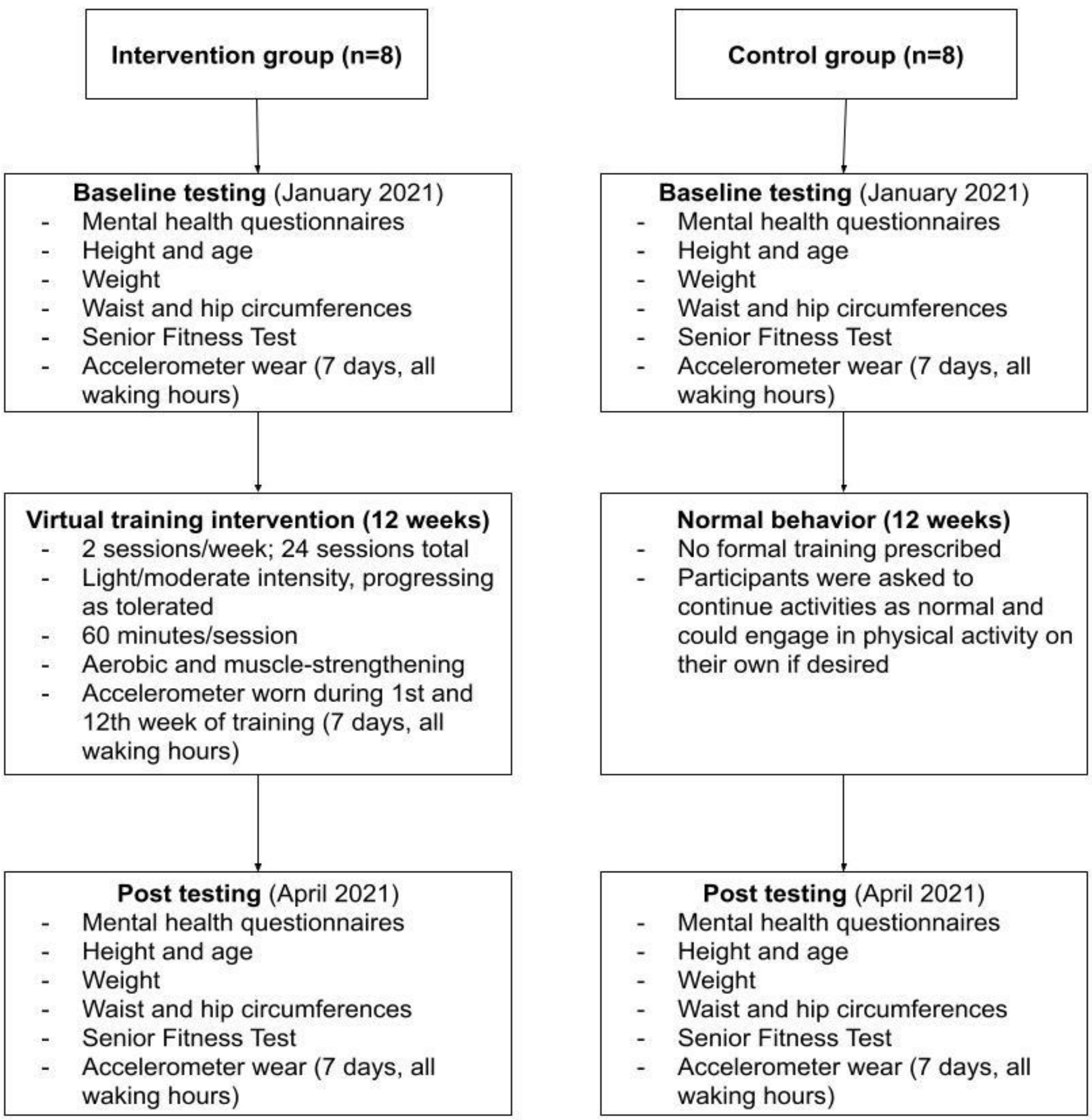

Figure 2. Flowchart of intervention procedures and timeline.

Post testing: Following completion of the exercise intervention (April 2021), participants completed the same mental health surveys and fitness testing measures as at baseline. Participants in both groups then wore an ActiGraph accelerometer on the wrist for one week, with data collected, processed, and analyzed in the same way as was completed at baseline in order to determine physical activity levels following the intervention.

Intervention fidelity: Adherence was assessed via an attendance log. Following each exercise session, participants were emailed a one-question, anonymous Qualtrics survey (Qualtrics Corp., Provo, UT, USA) in which they rated session acceptability (1-5 scale; 1 = poor and 5 = excellent). Finally, 15 sessions (~42% of sessions completed) were video recorded (eight in the first three weeks, seven in the final three weeks). We focused on sessions at the beginning and end of the intervention to determine if quality of the exercise sessions changed during the intervention; however, within the first and final three weeks, the sessions were chosen at random. One research assistant watched each video and answered 16 yes/no questions (found in Table 2) in order to assess session quality. Together, the participant adherence, acceptability survey responses and researcher evaluations of session quality were used to assess intervention fidelity.

Additionally, intervention participants completed a short exit survey. This survey asked about participant preferences for exercising virtually or in-person, their plans for being physically active following program completion, their desire to stay in the program if it could be continued or restarted, and had an open-ended question where participants could share their thoughts on the program.

Statistical Analysis

All variables met assumptions of normality and sphericity. Changes in variables measured at baseline and post testing were assessed using 2x2 (group x time) analysis of covariance, controlling for baseline levels in each variable and using a least significant difference test for post hoc, pairwise comparisons. Changes in accelerometer-measured physical activity from weeks 1 to week 12 of the intervention for the intervention group only were compared using two-sided paired-samples *t*-tests. In all analyses, a *p*-value of $p < 0.05$ was considered statistically significant. Effect sizes (ES) were calculated to assess magnitude of change from baseline testing to post-intervention time points, with ES < 0.20 = trivial, 0.20 ≤ ES < 0.50 = small, 0.50 ≤ ES < 0.80 = Medium, 0.80 ≤ ES < 1.30 = Large, and ES > 1.30 = very large (9). With a power of 0.8 and a sample size of 16 our study was insufficiently powered to detect significant differences unless effect sizes were of medium/large or greater magnitude (G*Power 3.0.10, (19)). All analyses were conducted in SPSS version 25.0 (IBM Corp., Armonk, NY, USA) and Microsoft Excel 2016.

Table 1. Example exercise sessions for the first and final week of the 12-week exercise intervention.

Exercise session components	Week 1	Week 12
Warm-up	Dynamic moves (15-60 seconds each) - Arm circles - Torso rotation - Chest expansions - March in place Static stretches (15-60 seconds each) - Hamstring - Quadriceps	Dynamic moves (15-60 seconds each) - Arm circles - Torso rotation - Chest expansions - March in place Static stretches (15-60 seconds each) - Hamstring - Quadriceps
Aerobic	Circuit - 40 seconds exercise, 20 seconds rest - Light/moderate intensity (talk test) - 3 sets - Exercises o Side steps o High knee steps o Elbow to knee steps o March in place o Alternating side-to-side punches	Circuit - 45 seconds exercise, 15 seconds rest - Moderate/vigorous intensity (talk test) - 5 sets - Exercises o Side steps o Lunges o High knee steps o Elbow to knee steps o Jumping jacks o Alternating side-to-side punches
Muscle-strengthening	Circuit - 12-15 repetitions per exercise - Light/moderate intensity (talk test) - 2 sets - Exercises o Wall push-ups o Body-weight squats o I-Y-T shoulder raises with resistance bands o Body-weight calf raises o Biceps curls with 2.2kg dumbbells o Supine crunches	Circuit - 10-12 repetitions per exercise - Moderate/vigorous intensity (talk test) - 3 sets - Exercises o Modified push-ups o Sit-to-stand squats with 4.5 kg dumbbells o I-Y-T shoulder raises with 2.3 kg dumbbells o Calf raises with 4.5 kg dumbbells o Biceps curls with 2.6kg dumbbells o Supine leg lifts o Prone low-back extension
Cool-down	Dynamic moves (15-60 seconds each) - Walk in place Static stretches (15-60 seconds each) - Hamstring - Quadriceps - Calf - Arm across body - Side bends - Arms above head	Dynamic moves (15-60 seconds each) - Walk in place Static stretches (15-60 seconds each) - Hamstring - Quadriceps - Calf - Arm across body - Side bends - Arms above head

Table 2. Quality assessment questions for exercise sessions.

Warm up	
1.	Targeted similar muscle groups to the main exercise
2.	Lasted 5-10 minutes
Aerobic exercise	
3.	Lasted at least 10 minutes
4.	Participants given opportunity to have at least 50% of time spent being active (e.g., rather than resting, talking, describing exercises)
5.	Exercise leaders determined intensity using talk test at least once every 5 minutes
6.	Included exercises individualized to participant needs and fitness level
Muscle-strengthening exercise	
7.	Lasted at least 10 minutes
8.	Participants performed at least one set of two different upper-body exercises
9.	Participants performed at least one set of two different lower-body exercises
10.	Participants performed at least one set of two different core exercises
11.	Exercise leaders determined intensity using talk test at least once every 5 minutes
12.	Included exercises individualized to participant needs and fitness level
Cool-down	
13.	Targeted similar muscle groups to the main exercise
14.	Lasted 5-10 minutes
Overall	
15.	Exercise leaders were generally attentive to participants' needs and questions
16.	The participants subjectively seemed to enjoy the exercise session based on demeanor, comments, body language

RESULTS

Mental health: Significant time effects were found for the ONS questionnaire, with increased (improved) scores at post-intervention testing and large ES for both groups (Figure 3, Table 3). NEF questionnaire findings were not different between time points for either group (small ES). Similarly, there were no differences between groups nor significant changes between baseline and post testing for PHQ-9 scores, although ES were trivial for the intervention group but medium (in a favorable direction) for the control group.

Physical fitness: Analyses revealed significant group effects for multiple variables (Figure 4, Table 3), with intervention participants having higher body weight and BMI and lower fitness for all tests except the sit-and-reach and back scratch tests. There was a significant time effect and group x time interaction for body weight and BMI, where only the intervention group decreased body weight (average change 3.1 kg) and BMI (average change 1.2 kg/m^2) at post-testing. There was a significant time effect for waist/hip ratio, significantly decreasing in both groups at post-testing (average change 0.03 for intervention group, 0.02 for control group). Effect sizes were very large for weight and BMI and medium for waist/hip ratio in the intervention group, and they were trivial for weight and BMI and large for waist/hip ratio in the control group. Measures from the fitness testing indicated significant time effects for 2-minute step test, 30-

second arm curl, and 30-second chair stand, improving at post-testing in both groups. Effect sizes were large for the 2-minute step test and 30-second arm curl and medium for the 30-second chair stand test in the intervention group, whereas ES were large for the 2-minute step test and 30-second chair stand test and medium for the 30-second arm curl test in the control group. A significant time effect was present for the 2.5-meter TUG test, with significant improvements (and large ES) in the intervention group only at post-testing. Flexibility test scores did not change in either group and have trivial to medium ES from baseline to post-testing.

Physical activity: Significant group effects and group x time interactions were found for steps/day and counts/day (Figure 5, Table 3), with greater steps/day and counts/day in the control group compared to the intervention group at post-testing (medium or large ES) and non-significant trends toward increases in steps and counts at post-testing in the control group only. No time or group effects were found for time spent in physical activity intensities, but a group x time interaction was found for MVPA, where the control group non-significantly trended toward higher MVPA at post-testing (medium ES) whereas the intervention group non-significantly trended toward lower MVPA at post-testing (large ES). Accelerometer-derived metrics in the 1st and 12th weeks of the intervention for the intervention group (Table 4) revealed no significant differences and trivial/small ES for all measured variables.

Fidelity: Participants attended a total of 140 out of 192 possible exercise sessions for an adherence of 72.9%, with a range of 13 (54.2% adherence) to 23 (95.8% adherence) sessions attended by participants. There were 107 responses to the exercise acceptability survey (76.4% survey completion), with a mean ± standard deviation of 4.7 ± 0.6 out of 5, a mode of 5 (82 responses), and only three responses ≤ 3. Analysis of the video-recorded exercise sessions for exercise session quality revealed an average score of 12.7 ± 0.6 (minimum 12 and maximum 14 out of 16). Most items were completed satisfactorily in 100% of exercise sessions. However, the most often missed items were warm-ups and cool-downs being < 5 minutes (70% of sessions) and that the Talk Test was not used at least every 5 minutes to assess activity intensity during aerobic and muscle-strengthening activities (90% of sessions).

In the exit survey, 75% of intervention participants preferred to exercise with others but would have preferred to be in person rather than virtual. Only 50% reported planning to maintain or increase physical activity levels following program completion. However, 100% expressed a desire to continue with the program if it were continued or restarted in the near future. Additionally, no intervention-related injuries/adverse events were reported. In the exit survey, participants also commented on building authentic relationships with their fellow participants as well as their exercise leaders, and the trust and friendships engendered in this setting gave participants strong motivation to attend sessions and give good effort (44).

Table 3. Mental health, physical fitness, and physical activity effect size and ANCOVA output data at baseline and post-testing.

	Effect sizes		ANCOVA outputs		
Mental health data	**Intervention**	**Control**	**Group**	**Time**	**Interaction**
NEF	0.35	0.47	F(1,14) = 0.1 *p* = 0.751	F(1,14) = 2.5 *p* = 0.133	F(1,14) = 0.0 *p* = 1.000
ONS	0.88	0.86	F(1,14) = 0.2 *p* = 0.662	F(1,14) = 12.0 *p* = 0.004	F(1,14) = 0.0 *p* = 1.000
PHQ-9	0.00	0.78	F(1,14) = 0.5 *p* = 0.491	F(1,14) = 1.4 *p* = 0.263	F(1,14) = 1.3 *p* = 0.281
Physical fitness data					
Weight (kg)	2.98	0.12	F(1,14) = 7.3 *p* = 0.016	F(1,14) = 35.1 *p* < 0.001	F(1,14) = 40.7 *p* < 0.001
Body mass index (kg/m^2)	3.72	0.10	F(1,14) = 6.1 *p* = 0.029	F(1,14) = 43.2 *p* < 0.001	F(1,14) = 47.2 *p* < 0.001
Waist/hip ratio	0.79	0.90	F(1,14) = 0.2 *p* = 0.709	F(1,14) = 7.7 *p* = 0.015	F(1,14) = 0.7 *p* = 0.431
2-minute step test (# steps)	1.06	1.03	F(1,14) = 4.6 *p* = 0.047	F(1,14) = 17.4 *p* = 0.001	F(1,14) = 0.1 *p* = 0.827
30-second arm curl (# curls)	0.93	0.76	F(1,14) = 7.7 *p* = 0.012	F(1,14) = 13.1 *p* = 0.003	F(1,14) = 0.3 *p* = 0.599
30-second chair stand (# stands)	0.73	0.85	F(1,14) = 5.8 *p* = 0.032	F(1,14) = 10.0 *p* = 0.007	F(1,14) = 0.4 *p* = 0.523
2.5 meter timed up-and-go (sec)	1.09	0.52	F(1,14) = 4.7 *p* = 0.044	F(1,14) = 4.9 *p* = 0.039	F(1,14) = 3.0 *p* = 0.104
Chair sit-and-reach (cm)	0.53	0.61	F(1,14) = 0.2 *p* = 0.700	F(1,14) = 3.6 *p* = 0.081	F(1,14) = 0.0 *p* = 0.931
Back scratch (cm)	0.18	0.31	F(1,14) = 0.4 *p* = 0.553	F(1,14) = 1.3 *p* = 0.270	F(1,14) = 0.0 *p* = 0.985
Physical activity data					
Wear-time (minutes/day)	0.66	0.66	F(1,12) = 2.0 *p* = 0.182	F(1,12) = 4.6 *p* = 0.069	F(1,12) = 2.3 *p* = 0.156
Steps/day	0.57	1.02	F(1,12) = 4.9 *p* = 0.041	F(1,12) = 0.0 *p* = 0.922	F(1,12) = 7.3 *p* = 0.019
Counts/day	0.84	0.89	F(1,12) = 5.7 *p* = 0.034	F(1,12) = 0.3 *p* = 0.591	F(1,12) = 10.4 *p* = 0.007
SED (minutes/day)	0.14	0.66	F(1,12) = 1.8 *p* = 0.200	F(1,12) = 0.0 *p* = 0.984	F(1,12) = 2.5 *p* = 0.137
LPA (minutes/day)	0.28	0.18	F(1,12) = 0.0 *p* = 0.946	F(1,12) = 0.6 *p* = 0.469	F(1,12) = 0.0 *p* = 0.872
MVPA (minutes/day)	0.89	0.61	F(1,12) = 2.8 *p* = 0.117	F(1,12) = 0.0 *p* = 0.961	F(1,12) = 5.5 *p* = 0.037

NEF: Short Warwick-Edinburgh Mental Well-being Scale. This scale is out of 35 points, where higher scores indicate better general mental wellbeing; ONS: Office for National Statistics' Measuring National Well-being scale. This scale is out of 40 points, where higher scores indicate better general mental wellbeing; PHQ-9: Patient Health Questionnaire. This scale is out of 36 points, where lower scores indicate lower depressive symptoms; SED: sedentary behaviors; LPA: light-intensity physical activity; MVPA: moderate- to vigorous-intensity physical activity; ANCOVA: 2x2 analysis of covariance.

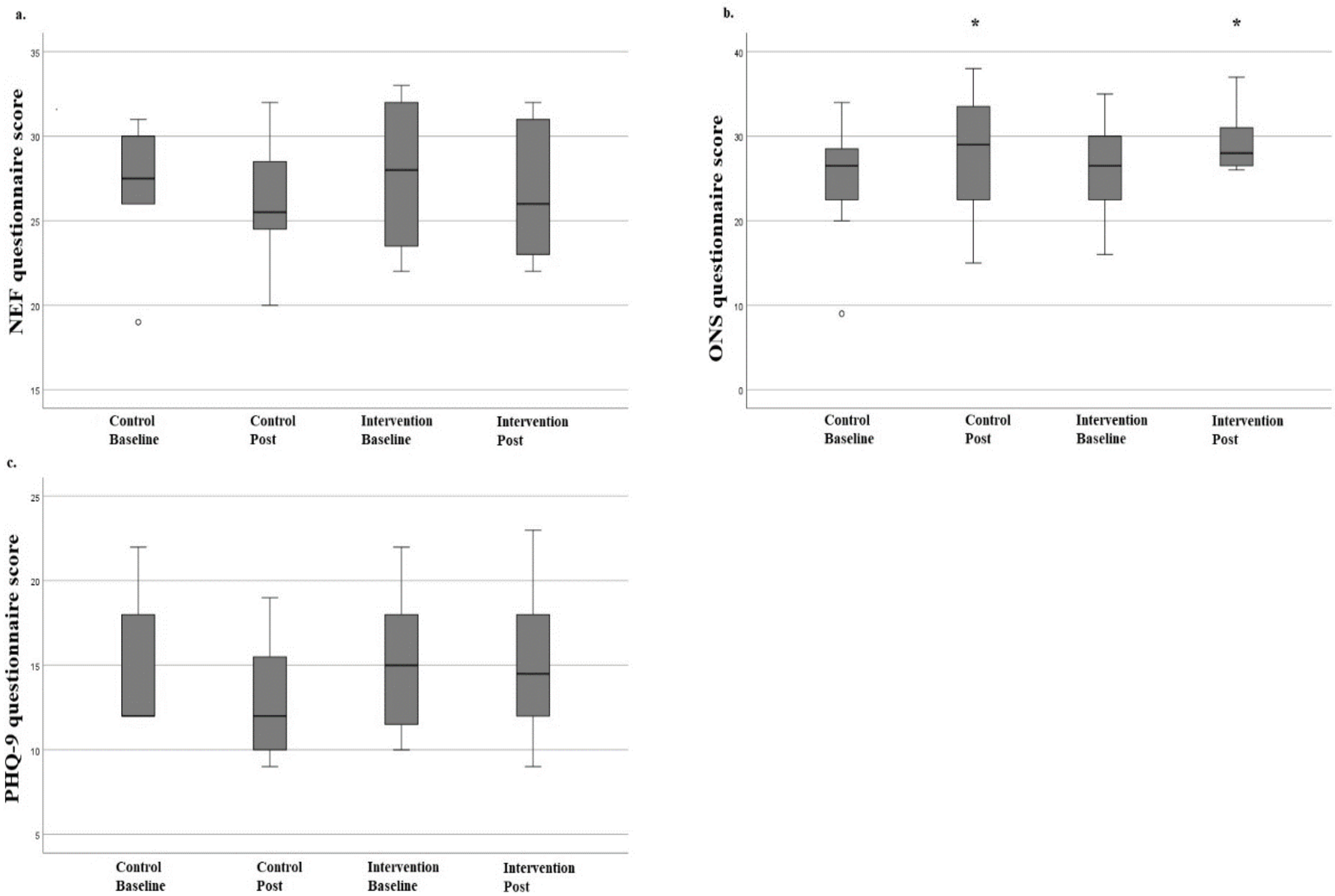

Figure 3. Mental health data at baseline and post-testing.
Data are shown as boxplots, with horizontal line representing median, top and bottom edges of the box representing interquartile range, and whiskers representing minimum and maximum.
° represent outliers in data.
NEF: Short Warwick-Edinburgh Mental Well-being Scale. This scale is out of 35 points, where higher scores indicate better general mental wellbeing.
ONS: Office for National Statistics' Measuring National Well-being scale. This scale is out of 40 points, where higher scores indicate better general mental wellbeing.
PHQ-9: Patient Health Questionnaire. This scale is out of 36 points, where lower scores indicate lower depressive symptoms.
*Indicates significant difference from baseline ($p < 0.05$) using 2x2 (group x time) analysis of covariance.

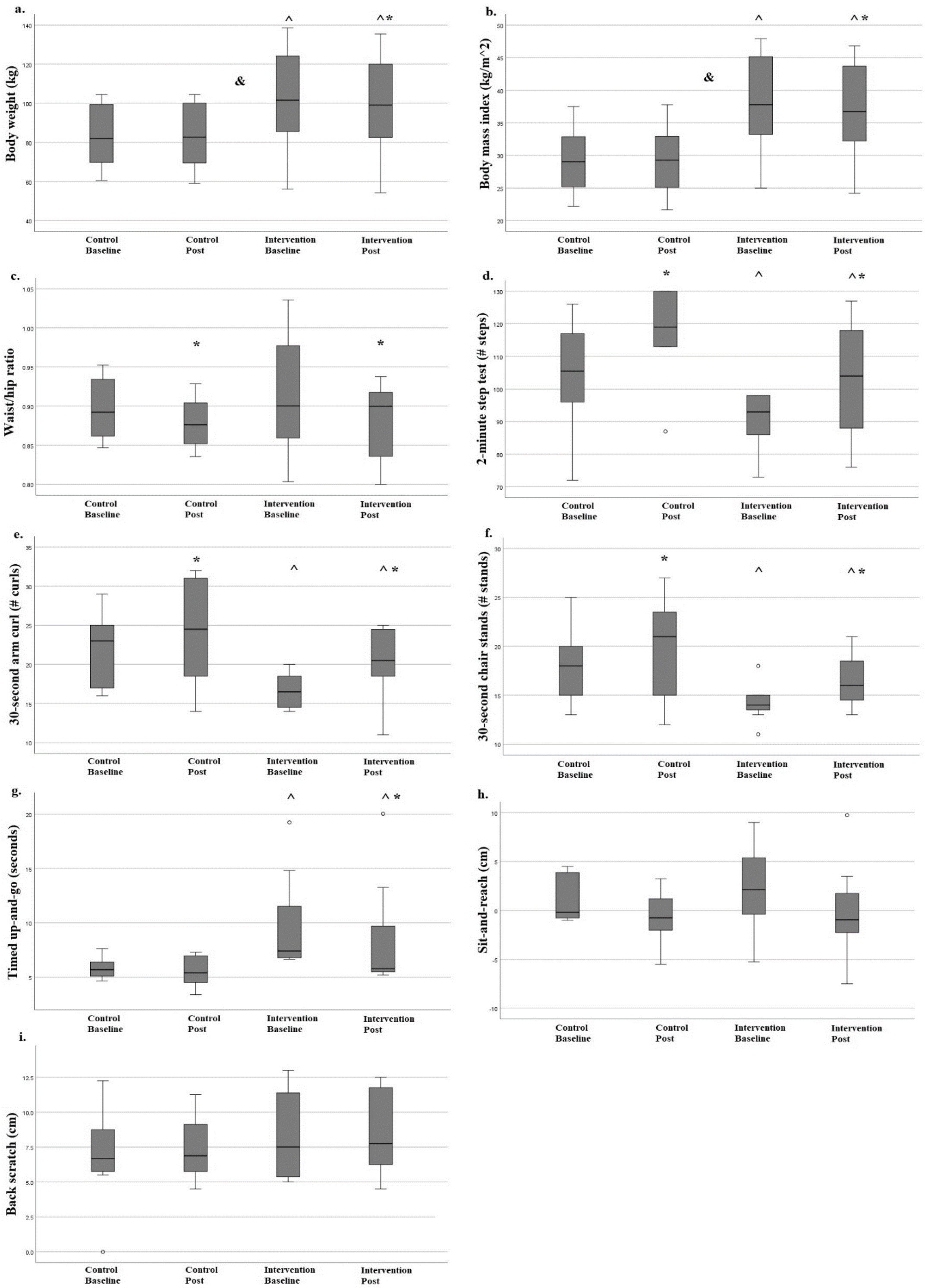

Figure 4. Physical fitness data at baseline and post-testing.
Data are shown as boxplots, with horizontal line representing median, top and bottom edges of the box representing interquartile range, and whiskers representing minimum and maximum.
° represent outliers in data.
*Indicates significant difference from baseline ($p < 0.05$) using 2x2 (group x time) analysis of covariance.
^Indicates significant difference from control group ($p < 0.05$) using 2x2 (group x time) analysis of covariance.
&Indicates significant group x time interaction using 2x2 (group x time) analysis of covariance.

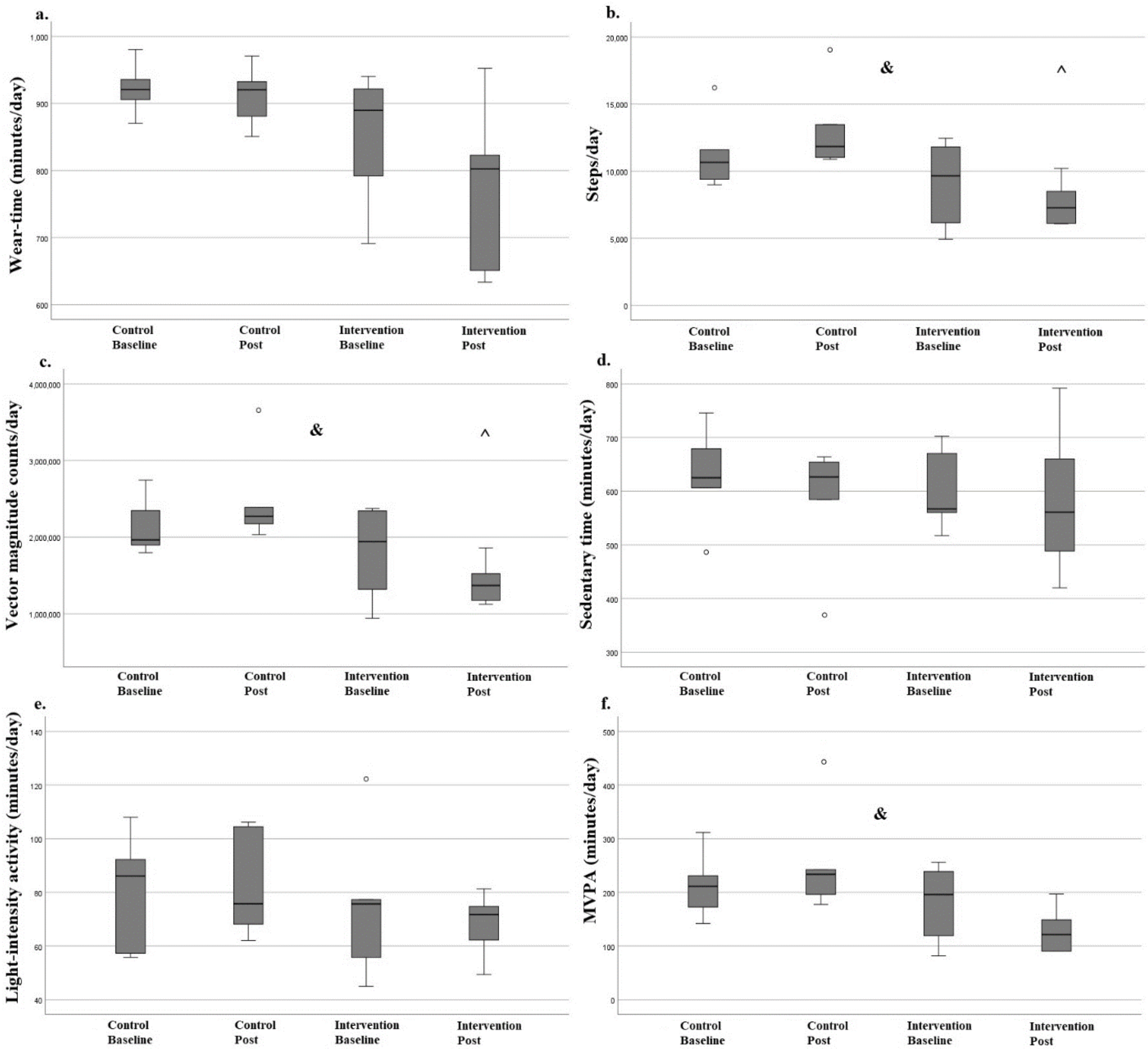

Figure 5. Accelerometer-measured physical activity data at baseline and post-testing.
Data are shown as boxplots, with horizontal line representing median, top and bottom edges of the box representing interquartile range, and whiskers representing minimum and maximum.
° represent outliers in data.
MVPA: moderate- or vigorous-intensity physical activity.
*Indicates significant difference from baseline ($p < 0.05$) using 2x2 (group x time) analysis of covariance.
^Indicates significant difference from control group ($p < 0.05$) using 2x2 (group x time) analysis of covariance.
&Indicates significant group x time interaction using 2x2 (group x time) analysis of covariance.

Table 4. Accelerometer-measured physical activity for the intervention group in the 1st and final (12th) week of the intervention.

Physical activity data	1st week	12th week	*p*-value	Effect size
Wear-time (minutes/day)	878.5 (61.2)	845.7 (61.6)	0.452	0.67
Steps/day	9,038 (2,443)	8,597 (1,562)	0.422	0.36
Counts/day	1,783,905 (429,109)	1,690,353 (254,291)	0.404	0.37
SED (minutes/day)	619.6 (76.5)	601.9 (98.8)	0.683	0.18
LPA (minutes/day)	84.5 (23.4)	81.7 (23.6)	0.664	0.19
MVPA (minutes/day)	174.1 (52.7)	162.0 (34.6)	0.361	0.41

Data are shown as mean (standard deviation). Analysis was paired-samples t-test.
1st week: accelerometer-derived physical activity during first week of exercise training in the intervention group.
12th week: accelerometer-derived physical activity during final week of exercise training in the intervention group.
SED: sedentary behaviors.
LPA: light-intensity physical activity.
MVPA: moderate- or vigorous-intensity physical activity.

DISCUSSION

Our pilot study tested a 12-week virtual exercise intervention during the COVID-19 pandemic and found significant improvements in some mental health and physical fitness variables but no change in physical activity levels in those completing the program. Additionally, good intervention fidelity was observed.

Mental health improved by a similar magnitude in both groups, with no differences between groups or interaction effects. Therefore, while we are encouraged by the positive changes in both groups, it seems that the improvements in mental health in the intervention group may more likely be due to seasonal or pandemic effects than to the exercise intervention itself. Given that COVID-19 cases were substantially higher in April (2,728-8,365 new cases/day) than in January (1,000-3,981 new cases/day) in Michigan (7), better weather (April has warmer weather than January in Michigan) and more hours of daylight may have played larger role in positive mental health changes than the state of the pandemic or, indeed, the exercise intervention.

In examining physical fitness changes, intervention participants lost an average of 3.1 kg (range 1.8-5.0 kg) in body weight during the program despite no dietary guidance provided. All participants were overweight or obese to start the program and listed weight loss as a primary program goal, so the demonstrated weight loss was a particularly positive finding. However, given the starting BMI levels of the participants, further weight loss from this sample would be needed to have greater clinical relevance or meet weight loss goals. Participants also overwhelmingly improved aerobic fitness, muscular fitness, and ability to complete agility/balance tests, such as the TUG test, with medium or large effect sizes. These findings suggest that our participants had a well-rounded training adaptation to the exercise intervention. This is in contrast to weight gain and fitness decrements (14), poor diet, and decreased physical activity levels seen during the pandemic (14, 40). Therefore, even the maintenance of physical activity levels in the intervention group may be viewed as positive considering the potential for decreases that could have occurred. Additionally, the favorable physical fitness changes are in line with traditional interventions in similar populations during non-pandemic times (13). Encouragingly, participants made numerous improvements in fitness during the intervention despite a modest dose of only two sessions per week targeted to be moderate intensity (progressing from light intensity early in program), and with minimal equipment. Such improvements would be expected to translate to improved activities of daily living (12).

Our control group did not lose weight but experienced improvements in several fitness constructs even without assignment to an exercise intervention; this could have been due to favorable weather shifts or changes in pandemic restrictions. The control group also increased their physical activity levels from baseline to post intervention, which may have contributed to their fitness improvements. Therefore, while we cannot fully rule out weather and pandemic restriction changes for some of the improvements seen in our intervention group, we speculate that our intervention was at least somewhat responsible for the beneficial effects, especially to weight loss and physical fitness improvements, in intervention participants.

In examining intervention fidelity, adherence (~73%) was higher than similar, in-person interventions conducted at our local recreation facility in past years (adherence 60-65%; unpublished observations) and in a larger trial in Canada during the pandemic (n = 162, adherence of 32-66% across a 12-week intervention) (2). Relatedly, participants gave overwhelmingly positive survey responses from the daily participant acceptability surveys. Session quality as assessed by researcher review of the videos was also consistently high, showcasing the possibilities for carrying out high-quality exercise sessions even through an online mode and with minimal equipment. The agreement between participant perceptions and research evaluations of high session quality likely contributed to the high adherence seen in our intervention. Additionally, we were able to address commonly cited barriers, including lack of knowledge and safety concerns, by having trained exercise leaders supervise and lead sessions in real time. As exercise sessions took place in the home, issues with lack of time or access to a facility were also mitigated. Finally, the majority (75%) of participants in the intervention group reported preferring to exercise with others, and the small-group format of exercise sessions likely created relatedness and accountability (4) and may have even led to more effective exercise completion (10). Especially as loneliness has been a common issue throughout the pandemic (24), our exercise sessions may have provided needed social interaction for participants and increased program adherence. While participants seemed to prefer if the exercise program could be in person, adherence and an expressed willingness to continue the program shows its promise as a future strategy for delivering high-quality exercise sessions and improving physical fitness in populations who may not have access to traditional, in-person exercise opportunities. Our study, focused in adults with chronic disease, adds to a growing both of research showing efficacy of home-based exercise programs for a variety of populations (1, 18, 23, 39).

Interestingly, while participants reported wanting to continue in the exercise program, only half intended to maintain or increase physical activity on their own. Accelerometer data supported survey responses, showing sustained activity levels from the beginning to the end of the program but a drop in point estimates of steps and MVPA in the first week following intervention completion. While the sample size is too small to reach definitive conclusions, it appears that our participants were able to exercise effectively in a structured, supervised exercise setting with exercise leaders, peer support, and access to a safe way to engage in exercise, but they did not readily exercise on their own when there was not accountability or oversight. The exit survey responses suggesting that participants were motivated by accountability to fellow participants in their sessions and the relationship with their exercise partner strengthens the reason for these findings. Our results are corroborated by findings in cardiac rehabilitation and physical therapy settings, which typically have higher adherence during structured programming than for unsupervised exercise (17, 47). This indicates that long-term exercise programming may be necessary to maintain physical activity levels and improve physical fitness in such populations.

The primary strengths of our study included contact-free, objective assessments of physical fitness and physical activity and a virtual programming format for adults with chronic disease to mitigate the impact of pandemic restrictions. Our study also had several limitations which should be considered. First, our small sample size and single geographical area limits our study's generalizability. Second, the assignment to control and intervention conditions was not randomized, so it is not possible to attribute health and fitness benefits in the intervention group solely to the exercise intervention. Since the control group made mental health and some fitness improvements throughout the study, it is possible that some of the improvements seen in our intervention group are due to seasonal/weather effects or changes in pandemic restrictions. Third, while our participants had chronic disease, all were able to get physician approval to exercise prior to beginning our program. Those with chronic disease but without access to a healthcare provider to clear them for exercise participation should be cautious, especially with regard to exercise intensity, if planning to engage in home exercise. Fourth, while adherence was high for participants starting the exercise program, < 20% of participants originally contacted had access to internet or were interested in home-based exercise. Thus, this form of training may increase exercise participation only in a small subset of inactive adults with chronic disease. Finally, although intervention components addressed tenants of Self-Determination Theory, at this stage we did not formally evaluate if the psychological constructs associated with the theory were impacted by the intervention. Our intent is to do so in the future.

In conclusion, our pilot study found that a virtual exercise training program was delivered with high fidelity and resulted in fitness improvements in previously inactive adults with chronic disease during the COVID-19 pandemic. These findings and previous work suggest that home-based, supervised exercise programming should be considered alongside traditional training modalities, even beyond the pandemic, to promote physical fitness and maintain physical activity levels in adults with chronic disease.

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