Feasibility of a Group-Based Telerehabilitation Intervention for Long COVID Management.

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Abstract

Background and objective:

The increasing awareness of the prevalence and chronic nature of the COVID-19 disease burden requires a better understanding of effective interventions in large scale clinical trials. Telerehabilitation is effective in other chronic disease groups and the aim of this study was to assess the feasibility of a specific, group-based telerehabilitation exercise intervention for Long-COVID.

Methods

People with Long-COVID symptoms, defined as persistent dyspnoea, fatigue or chest pain, at least 110 days post COVID-19 diagnosis and who had not undertaken exercise training three months prior to randomisation into the trial were included. Participants were randomised to receive a twice-weekly supervised group telerehabilitation program for ten weeks or continue with usual care. Feasibility outcomes included recruitment rate, adherence, completion rate, adverse events and technological issues. Exploratory clinical outcomes including exercise capacity, fatigue and health-related quality of life were also assessed.

Results

21 participants with mean age 53 ± 14 yrs, 17 of whom were not hospitalised, were recruited 365 ± 67 days after diagnosis of COVID-19. The recruitment rate was 39% of possible participants. Nine (82%) of the intervention group completed the follow-up assessments. The telerehabilitation participants completed 18 ± 2 sessions, with 100% completing 16 sessions or more. There were no adverse events and two technological problems reported for the intervention group.

Conclusion

Supervised group telerehabilitation appears to be feasible and safe for people with Long-COVID. A future study is required to examine the efficacy and generalizability of the supervised group-based telerehabilitation exercise intervention.

Trial registration:

Australian New Zealand Clinical Trials Registry (Trial ID: ACTRN12621000031864)

Key Messages Regarding Feasibility

- Telerehabilitation is used in chronic diseases such as COPD but the feasibility of group telerehabilitation in people with Long-Covid is not yet known
- Our trial has demonstrated the feasibility of recruitment, adherence and completion of a group telerehabilitation program in Long-Covid
- Using the pilot data and feasibility results, a larger study could be developed to evaluate the efficacy of telerehabilitation in Long-Covid

Background

The COVID-19 pandemic has resulted in an unprecedented global health crisis, impacting health care systems with over 445 million people infected with severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) and close to 6 million related deaths reported globally prior to March 7 2022. [1] COVID-19 disease, caused by SARS-CoV-2 can result in multiple organ dysfunction and cause a wide spectrum of acute symptoms at presentation. [2] Early research efforts in the COVID-19 pandemic were focussed on managing the acute illness and reducing mortality. However, there are increasing concerns of an associated level of chronic morbidity, persisting long after the acute infection period and unrelated to the severity of the index illness. [3] Persistent symptoms of residual COVID-19 include shortness of breath, persistent fatigue, “brain fog”, muscular weakness, chest pain, cognitive impairment and joint pain resulting in reduced physiological, mental and functional capacity as well as health related quality of life (HRQoL). [4] Chronic COVID-19 syndrome or Long-COVID-19 (Long-COVID) are terms used to describe the persistent symptoms extending three months beyond the acute period of infection. The true incidence of Long-COVID remains contested with studies reporting a range of 10–20% among non-hospitalised patients [5, 6] and 51 to 76% of patients reporting at least one symptom at four months following hospitalisation [7, 8] Despite impacting people regardless of initial disease severity, [9] Long-COVID presentations appear similar in some ways to that of the reported in post-intensive care syndrome which causes impairments in physical, emotional and cognitive health. [10]

Given the incidence of SARS-CoV-2 globally, there is now a large number of people who are at risk of developing Long-COVID with significant implications for rehabilitation service delivery. There is an urgent need to better understand the feasibility and safety if interventions to manage people with Long-COVID. Pulmonary rehabilitation (PR) exercise programs are highly effective in reducing respiratory symptoms and improving physiological functional capacity in patients who present with respiratory diseases such as chronic obstructive pulmonary disease (COPD) and interstitial lung disease. [11, 12] PR programs can be delivered effectively in outpatient/community settings and via tele-health utilising supervised videoconferencing. [13] For COVID-19, international guidelines recommending access to rehabilitation services for patients with persistent symptoms [14] but, to date, there are limited studies investigating the effects of different specific rehabilitation programs in this population.

This randomised pilot trial aimed to evaluate the feasibility of a supervised group telerehabilitation intervention for people with Long-COVID. A secondary aim was to collect descriptive statistics on clinical outcomes that may be relevant for planning future, larger studies in this population.

Methods

Trial design

This was a prospective, single centre, randomised pilot trial that was undertaken between March 2021 and August 2021.The reporting of this pilot trial followed the Consolidated Standards of Reporting Trials for pilot and feasibility studies (CONSORT) [15]and Template for Intervention Description and Replication (TIDieR) guidelines.[16]The trial was approved by the Sydney Local Health District Human Research Ethics Committee (**X20-0545 & 2020/ETH03228**) and was registered prospectively withthe Australian and New Zealand Clinical Trials Registry (Trial ID: ACTRN12621000031864).

This trial was a sub-study of an ongoinglongitudinal observational cohort investigation of people with confirmed SARS-CoV-2 infection led by St Vincent's Hospital, Sydney Australia (ADAPT). The ADAPT study included people with COVID-19 disease, regardless of severity, who participated in a broad range of assessments to comprehensively characterize the immune-pathobiological effects of COVID-19 disease. [17]From the ADAPT cohort, participants who reported ongoing symptoms, defined as persistent dyspnoea, fatigue or chest pain, at any time-point after 110 days post diagnosis were screened for inclusion in this trial.

Participants

Participants were eligible for enrolment if they had consented to the ADAPT study, were aged 16 years and over and had ongoing symptoms of Long-COVID,defined as persistent dyspnoea, fatigue or chest pain at any time beyond 110 days post SARS-Cov-2 diagnosisPatients were excluded if they had pre-existing lung disease amenable to pulmonary rehabilitation eg COPD, had completed supervised exercise training in the 3- month period prior, had a household member already recruited to this sub-study, or were unable to participate due to other medical conditions or unwilling to participate intelerehabilitation. The reason for declining participation was recorded.

Participants were contacted via telephone by a member of the investigating team to be screened for eligibility. Consenting eligible participants underwent a standardised in-person baseline assessment during the enrolment visit.

Randomisation

After the enrolment visit, participants were randomised (1:1) using a computer generated randomisation (www.sealedenvelope.com) with concealed allocation to one of two groups: 1) telerehabilitation that included supervised exercise training over videoconferencing; and 2) a control group who performed no supervised exercise training over the study period.

Interventions

Telerehabilitation Intervention Group

The group telerehabilitation exercise intervention was based on previous telerehabilitation programs that have beenreported to be effective in patients with COPD.[18]Participants allocated to the intervention groupwere given instructions via email to set up a home-based exercise area and advised of equipment requirements; a walking track free of clutter, weighted objects to use as hand weights and a stable chair. An instructional copy of the Borg dyspnoea scale was also provided along with links to join the videoconferencing platform. All telerehabilitation sessions were conducted by physiotherapists at St Vincent's Private Hospital Sydney, in groups of up to six participants, twice weekly for ten weeks with participants needing to complete at least 16 sessions to meet an exercise adherence definition and to allow for sessions missed due to illness or other commitments. The telehealth exercise sessions consisted of walking training, upper and lower limb strengthening and combination aerobic movements with modifications made so that the participants were exercising at a rating of three to five on the modified Borg scale (0-10) for dyspnoea and perceived exertion.[19]

A detailed example of an exercise session is shown in Supplement 1. Participants were not given any specific exercise prescription to complete on other days.

Control group

Participants allocated to the control group received usual medical care and participation in other observational components of the larger longitudinal ADAPT study. The control group did not participate in supervised exercise training and were not given any advice regarding exercise training. The control group were offered access to the same tele-rehablilitation sessions or individual physiotherapist advice after completion of their control period.

Follow-up

All participants attended one in-person visit at enrolment and one at the completion of the study at St Vincent's Private Hospital Sydney. On both visits, all outcome measures were collected by physiotherapists who were blinded to the group allocation with no involvement in any components of the telerehabilitation program. Participants in the trial and the physiotherapists who were blinded to the group allocation were instructed not to discuss the intervention received when undertaking the outcome assessment procedures.

Outcome measures

Feasibility outcomes

The primary feasibility outcomes for this pilot trial were i)study recruitment rate, ii)adherence rate to the telerehabilitation program, iii) completion rate, iv) adverse events during the telerehabilitation program and v) technological issues limiting participant participation. The recruitment rate wasdefined as the number of patients that met the inclusion criteria who then were enrolled in the study divided by the number of patients contacted to be invited to the study. The adherence to the telerehabilitation program was measured by the percentage of enrolled patients who completed at least 16 of the 20 exercise

sessions. Completion was measured as the percentage of participants who were followed-up successfully after completing the follow-up assessments during the follow-up visit. Safety was measured by the number of adverse events reported during the telerehabilitation period. Technological issues limiting connectivity to and participation in the telerehabilitation sessions were also recorded.

Exploratory Clinical Outcomes:

Exploratory clinical data-collection measurements included i) six-minute walk test, ii) health-related quality of life, iii) perceived level of fatigue, iv) five repetition sit to stand test, v) gait speed and vi) handgrip grip strength.

Six-minute Walk Test

Physiological functional capacity was estimated using the six-minute walk test (6MWT). Two 6MWTs were completed, at least 30 minutes apart,and followed standardised procedures.[20] The longest distance recorded from either of the two 6MWTs was used for analysis. The 6MWT result was compared to 6MWT estimates for healthy Australian individuals.[21] Peripheral oxygen saturation ($Sp0_2$) and heart rate (HR) were continuously monitored during the test with a pulse oximeter (Masimo-Rad-5v, Masimo Corporation, Irvine, Ca, USA). Perceived level of dyspnoea was determined before and after completion of each 6MWT using the modified 0-10 Borg scale of perceived dyspnoea. [19]

Health related quality of life

Health-related quality of life (HRQoL) was assessed by the St George's Respiratory Questionnaire (SGRQ). The SGRQ rates the HRQoL of people with chronic respiratory disease on a 0-100 scale with a increasing scores indicating decreasing HRQoL. [22]

Fatigue

Level of fatigue was assessed using the 0-52 point FACIT-Fatigue scale, with a score of less than 34 points indicating severe levels of fatigue. [23, 24]

Five repetition sit to stand test

The functional capacity of the quadriceps was measured using the five repetition sit to stand (5STS) test. The participants were asked to stand up and sit down from a 48cm chair, without using their arms, five times as fast as possible. The fastest of two tests was recorded for subsequent analysis. Participants who could not stand up without using their arms did not complete the 5STS test. [25]

Gait speed

Gait speed was assessed using the four-metre gait speed test (4MGS), with the testcompleted three times using a standardised procedure. The shortest time recorded was used for subsequent analysis.[26]

Handgrip strength

Handgrip strength was measured using a handgrip dynamometer (Jamar Plus Dynamometer, Cedaburg Wisconsin USA), with each hand tested alternatively three times. The average result for the dominant hand was used for subsequent analysis.[27]

Sample size

As a pilot feasibility study, the objective was to test trial procedures, recruitment potential and feasibility and safety. The future trial arising from this pilot will aim for a medium effect size with 80% power; as suchBell et al. [28] recommend 10 participants per arm in the pilot study.

Data analysis

Demographic and symptom variables were summarised using means and standard deviations for numerical variables and count with percentage for categorical variables. For each exploratory clinical outcome measure, mean scores and 95% confidence intervals (CI) were reported for each group together with the 95% CI for the mean difference between groups and difference in mean change. The latter intervals are provided for use with future trial sample size estimation and are not intended for inferential purposes. All statistical analyses were performed using R version 4.1.0. [29]

Results

Flow of Participants

The flow of patients throughout the trial is presented in Fig. 1. In March 2021 a total of 141 participants in the ADAPT longitudinal study were screened for Long-COVID symptoms among whom there were 54 participants who met the inclusion criteria and were invited to participate in the pilot trial. A total of 21 out of the 54 (39%) participants consented to this trial.

Among consenting participants, the average time between receiving a positive PCR for COVID-19 and commencing the study was 365 ± 67 days as most ADAPT study participants had Covid-19 in March/April 2020. The majority of participants were managed in the community with only four (19%) being hospitalised and of these one (5%) needed intensive care. Eleven participants were randomised to the telerehabilitation supervised exercise training group and ten to the control group. The study follow-up ended in August 2021 when all participants had completed the training protocol and had undergone a final assessment. The baseline characteristics of the participants are presented in Table 1.

Table 1
Baseline characteristics of patients

	Telerehabilitation Group (n = 11)	Control Group (n = 10)
Age (years)	59.0 (13.6)	46.5 (13.1)
Male	6 (54.5)	4 (40.0)
BMI (kg/m^2)	26.9 (3.8)	25.9 (4.7)
Lung function	3.1 (0.8)	3.2 (0.7)
FEV_1	96.4 (17.7)	88.1 (21.3)
FEV_1% predicted	77.7 (6.2)	82.7 (4.0)
FEV_1/FVC%		
Days since COVID-19 diagnosis	352.3 (79.8)	380.0 (48.1)
Hospitalisation for COVID-19 with or without an ICU admission	3 (27.3)	1 (10.0)
Symptoms	10 (90.9)	8 (80)
Dyspnoea	9 (81.8)	7 (70)
Fatigue	4 (36.4)	4 (40)
Chest pain	4 (36.4)	4 (40)
Cough	1 (9.0)	1 (10)
Sputum		

BMI: body mass index; FEV: forced expiratory volume; ICU: intensive care unit; Numerical variables presented as mean and standard deviation (SD); categorical variables presented as count with percentage (%).

Feasibility Outcomes

Adherence with the telerehabilitation exercise sessions was high for the participants who completed the study, with the telerehabilitation group participants completing on average 18 ± 2 sessions, with 100% completing 16 sessions or more. The two that were lost to follow-up both withdrew from the study due to work and family commitments within one week of randomisation and attended two or less telerehabilitation intervention sessions. No adverse events were recorded during any of the telerehabilitation exercise sessions and no participants reported any severe post-exertional malaise that caused them to modify their work or social activity after any of the exercise sessions. There were no

adverse events recorded in the control group. There were only two minor technical difficulties reported during the telerehabilitation exercise sessions, both relating to poor audio quality from a participant's device that was managed by the clinician speaking to the participant over the telephone while viewing the participant via the computer screen.

Clinical Outcomes

The exploratory clinical outcome variables at enrolment and completion are presented in Tables 2 and 3. Analyses of the clinical outcome variables demonstrate wide variability. At baseline the intervention group walked significantly less distance than the control group during the 6MWT (516m vs 634m; $p < 0.05$). The 6MWT distance values at baseline in the intervention and control groups at baseline were 76% and 87% of predicted distance respectively and 5STS was within the normal range for most participants when adjusted for age. [30] For the baseline 6MWT and 5STS values, the significant difference between the intervention and control groups (Table 2) suggests that future large studies should consider using an analysis of covariance approach where follow-up differences are adjusted for baseline measurement. There were no between group differences at follow-up (Table 2) or in change scores (Table 3) in any clinical variables measured aside from improvements in 5STS values in favour of the intervention group (-1.4 seconds, 95% confidence interval − 0.2 to -2.6).

Table 2
Clinical outcome summaries

	Baseline mean (95%CI)			Follow-up mean (95%CI)		
Outcome	**Exercise Group (n = 11)**	**Control Group (n = 10)**	**Difference**	**Exercise Group (n = 9)**	**Control Group (n = 9)**	**Difference**
6MWT (m)	516 (434, 598)	634 (579, 690)	-118 (-211, -24)*	566 (445, 687)	651 (592, 710)	-85 (-212, 42)
Proportion of predicted 6MWT distance (%)	0.76 (0.64, 0.88)	0.87 (0.81, 0.94)	-0.11 (-0.25, 0.02)	0.84 (0.70, 0.99)	0.89 (0.82, 0.97)	-0.05 (-0.20, 0.10)
SGRQ-T	27.9 (16.1, 39.7)	20.3 (8.09, 32.5)	7.6 (-8.2, 23.4)	21.8 (8.93, 34.6)	18.9 (6.16, 31.7)	2.9 (-13.8, 19.5)
SGRQ-S	30.1 (15.7, 44.4)	28.7 (12.8, 44.6)	1.4 (-18.7, 21.3)	21.6 (4.5, 38.7)	25.6 (11.1, 40.2)	-4.0 (-24.7, 16.6)
SGRQ-I	19.5 (6.9, 32.1)	13.5 (4.3, 22.7)	6.0 (-8.7, 20.6)	12.1 (1.4, 22.9)	14.2 (1.6, 26.8)	-2.1 (-17.3, 13.3)
SGRQ-A	41.3 (27.5, 55.2)	29.4 (11.1, 47.6)	11.9 (-9.4, 33.4)	39.0 (19.5, 58.5)	25.8 (9.3, 42.3)	13.2 (-10.3, 36.8)
FACIT-Fatigue scale	33.2 (25.9, 40.4)	36.5 (28.7, 44.3)	-3.3 (-13.2, 6.6)	39.9 (32.0, 47.8)	38.3 (30.0, 46.6)	1.6 (-9.0, 12.1)
5STS (sec)	8.6 (7.3, 10.0)	6.5 (5.2, 7.8)	2.1 (0.4, 3.9)*	6.8 (5.3, 8.3)	5.9 (4.7, 7.1)	0.9 (-0.8, 2.7)
4m Gait speed (sec)	2.9 (2.4, 3.3)	2.5 (2.2, 2.8)	0.4 (-0.1, 0.9)	2.7 (2.2, 3.2)	2.5 (2.2, 2.9)	0.2 (-0.4, 0.7)
Grip strength (kg)	27.5 (18.1, 36.9)	29.8 (25.1, 34.5)	-2.3 (-12.3, 7.7)	29.0 (17.1, 40.9)	31.2 (25.9, 36.4)	-2.2 (-14.5, 10.3)

6MWT: six minute walk test in metres, SGRQ-T: St George's Respiratory Questionnaire Total score, SGRQ-S: St George's Respiratory Questionnaire Symptom score, SGRQ-I: St George's Respiratory Questionnaire Impact score, SGRQ-A: St George's Respiratory Questionnaire Activity score, *=significant difference between exercise and control groups.

Table 3
Clinical outcome summaries

	Mean change (95%CI)		
Outcome	**Exercise Group (n = 11)**	**Control Group (n = 10)**	**Difference**
6MWT (m)	56.7 (-6.4, 119.8)	6.2 (-10.2, 22.6)	50.5 (-13.4, 114.3)
Proportion of 6MWT predicted distance (%)	0.07 (-0.01, 0.16)	0.01 (-0.01, 0.03)	0.06 (-0.02, 0.15)
SGRQ-T	-4.0 (-10.1, 2.0)	-3.3 (-10.7, 4.2)	-0.7 (-9.6, 8.1)
SGRQ-S	-6.8 (-18.2, 4.6)	-4.3 (-13.6, 5.1)	-2.5 (-16.1, 11.1)
SGRQ-I	-3.7 (-8.6, 1.2)	-0.8 (-7.9, 6.3)	-2.9 (-10.9, 5.1)
SGRQ-A	-2.9 (-17.1, 11.3)	-6.9 (-18.1, 4.4)	4.0 (-12.8, 20.7)
FACIT-Fatigue scale	7.7 (1.1, 14.3)	3.1 (0.8, 5.4)	4.6 (-2.2, 11.3)
5STS (sec)	-1.8 (-2.8, -0.9)	-0.4 (-1.3, 0.5)	-1.4 (-2.6, -0.2)*
4m Gait speed (sec)	-0.3 (-0.7, 0.2)	0.1 (-0.2, 0.4)	-0.4 (-0.8, 0.1)
Grip strength (kg)	2.4 (-0.9, 5.7)	2.0 (-0.2, 4.1)	0.4 (-3.2, 4.1)

6MWT: six minute walk test in metres, SGRQ-T: St George's Respiratory Questionnaire Total score, *=significant difference in change between exercise and control

Discussion

In this investigation we report feasibility findings for a randomised controlled trial of a supervised, group-based, telerehabilitation program delivered over 10 weeks for adults with symptoms of Long-COVID at one year post SARS-CoV-2 infection. This preliminary data is encouraging for the design of larger trials to investigate the effects of a supervised group-based telerehabilitation intervention for the management of Long-COVID symptoms. We report that the supervised group-based telerehabilitation delivered to participants with Long-COVID was feasible and safe. There were no adverse events, adherence was high with a recruitment rate consistent with previous pulmonary rehabilitation trials. [18, 31] As we expected, our exploratory results showed no statistically differences between the telerehabilitation and control arms of the trial aside from the 5STS. The exploratory results of this telerehabilitation intervention investigation should be interpreted with caution because the study design did not allow for inferences about the efficacy of the intervention. However the improvements in 6MWT and FACIT-Fatigue score for the intervention group, while not statistically significant, were encouraging and above the minimally important difference reported for these measures [20, 32] but this result needs to be replicated in a correctly powered sample.

Long-COVID is a recognised condition that has a prolonged and substantial impact on physiological functional capacity, fatigue, and quality of life. Long-COVID symptom presentations can present after the acute COVID-19 infection period regardless of the severity of the acute symptoms. [3] Our study supports this concept as our participants reported ongoing fatigue, reduced HRQoL and reduced exercise capacity even though a year had elapsed since their COVID-19 diagnosis and most of the participants did not require hospitalisation. While early clinical and research rehabilitation interventions have focussed on those patients with more severe disease in the acute period [33–35], a greater understanding of individuals who experience persistent symptoms is required to reduce to impact of this disease.

Since many hospital and rehabilitation services have been limited during the pandemic, particularly in countries with high rates of COVID-19, resources have been directed at those patients with the most acute requirements. This has resulted in many patients not having access to rehabilitation. Programs have now started to provide Long-COVID rehabilitation services for those patients with symptoms longer than three months with promising results. [36] However, our study included participants who were on average one year from their original diagnosis and identified that telerehabilitation is feasible and safe for those who have experienced symptoms for a longer duration and who were unable to access rehabilitation earlier. Inpatient and supervised outpatient rehabilitation programs for COVID-19 have been shown to be feasible [30–32], but these modes may not suit all individuals who present with Long-COVID symptoms, such as those who live far from health services or those with work or family commitments and these barriers have been shown to reduce pulmonary rehabilitation uptake in other disease groups like COPD. [37, 38] In order to increase the uptake and completion rates, rehabilitation services need to provide options to overcome these barriers in their patient group. As Long-COVID has severely impacted some individuals' ability to return to their previous occupation [2], telerehabilitation allows access for people who need to schedule services around their work commitments. Our study included an after-hours option for those participants who needed this flexibility.

The health burden and impact of Long-COVID occurs across all adult age groups and is not limited to those who were hospitalised or who had pre-existing health conditions. [17] Our study participants had a wide age range, varying levels of baseline function and were predominantly not hospitalised during the acute period. The scale and variability of those with Long-COVID presents challenges to planning and implementing effective and accessible rehabilitation programs. Previous COVID-19 telerehabilitation trials have focused on those who had been hospitalised, and have delivered in different formats including unsupervised home programs with telephone or phone app support [39] or with individual telerehabilitation sessions [40] demonstrating improvements in exercise capacity and symptoms. Our study is the first to report on the feasibility of a group-based telerehabilitation intervention in Long-COVID participants. Our intervention required minimal equipment and adherence was high. However, it is important to note that all of our participants had access to technology and regularly used videoconferencing platforms prior to the study. Therefore, we encountered less technological issues compared to previous telerehabilitation studies [18, 20] and fewer barriers to uptake of the intervention. Additionally, before our study began, our participants had undergone extensive medical investigations such as pulmonary function testing and cardiac investigations. These medical investigations undertaken

in a low number of participants may have contributed to there being no adverse events, since all participants were medically stable.

Our study design has several limitations that should be considered in planning a larger clinical trial. The exercise and control groups were heterogenous with wide variability in baseline physiological functional capacity, fatigue, and HRQoL measures. Differences in baseline clinical outcomes suggest the need for statistical analyses that adjust for baseline (analysis of covariance) in larger randomised trials. Larger randomised controlled trials can potentially investigate the effect of different types of rehabilitation interventions and the effect of telerehabilitation for Long-COVID participants who report different symptom presentations, such as those with breathlessness and/or fatigue. People with Long-COVID symptoms have also reported post-exertional malaise and conditions including postural orthostatic tachycardia. [41] Although these conditions were not reported for our participants, there may be a subgroup of Long-COVID patients who may not be suitable for this type of rehabilitation program. [42] Also, in order to ensure that the control group was unable to independently replicate the content of the telerehabilitation sessions, we excluded potential participants from the present study due to the previous recruitment of members of the same household. As household transmission of Covid-19 is common [43] there is the possibility of family members being eligible for the same trials. Future randomised trials may need to adapt their randomisation protocols to manage this issue to ensure participants in the same household do not participate in different arms of the trial. Unlike previous studies [18, 20], we did not complete a home-visit to set-up for each participant's exercise area. A home visit with each participant would have provided increased monitoring of the exercise intervention and progression of the program. Exercise prescription was based solely on the intensity of effort as indicated by shortness of breath, and this provided a practical solution to the monitoring issue. However, closer monitoring of the intensity of effort during the exercise intervention may be beneficial in larger trials that evaluate the efficacy of rehabilitation interventions in this group.

The clinical outcome measures used in this study are similar to those reported elsewhere [35, 36, 39] but the responsiveness to change of these measures needs to be further evaluated in Long-Covid particularly due to the wide variability of people with this condition. Our group had a high baseline 6MWT and 5STS relative to other trials [35, 39] despite reporting significantly reduced HRQoL and other changes to their usual level of physical function. Consequently, these tests may not have been as sensitive to change with rehabilitation interventions compared to other measures, such as the endurance shuttle walk test (ESWT) or one minute sit to stand test and may have under reported the effect of the exercise intervention for this trial. Further investigation in larger cohorts is required to identify the most appropriate measures to evaluate this population.

In conclusion, our study has shown that group supervised telerehabilitation is feasible and safe in people with Long-COVID. Further studies are required to evaluate the efficacy of telerehabilitation in this cohort.

Declarations

Ethics approval: The study was approved by the Sydney Local Health District Human Research Ethics Committee (**X20-0545 & 2020/ETH03228**).

Consent for publication: Nil individual data used in this manuscript. All participants signed written consent forms for participation and publication of results

Competing interests: The authors declare that they have no competing interests

Data availability:The datasets during and/or analysed during the current study available from the corresponding author on reasonable request.

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Author contributions: MK, SM, AB developed study protocol, study recruitment and staff training. PG developed statistical analysis plan and results. LD contributed to development of analysis plan. PD, AS and EB assisted in protocol development and data collection. AP, EK, BD contributed to development and delivery of intervention. All authors significantly contributed to manuscript preparation.

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Figures

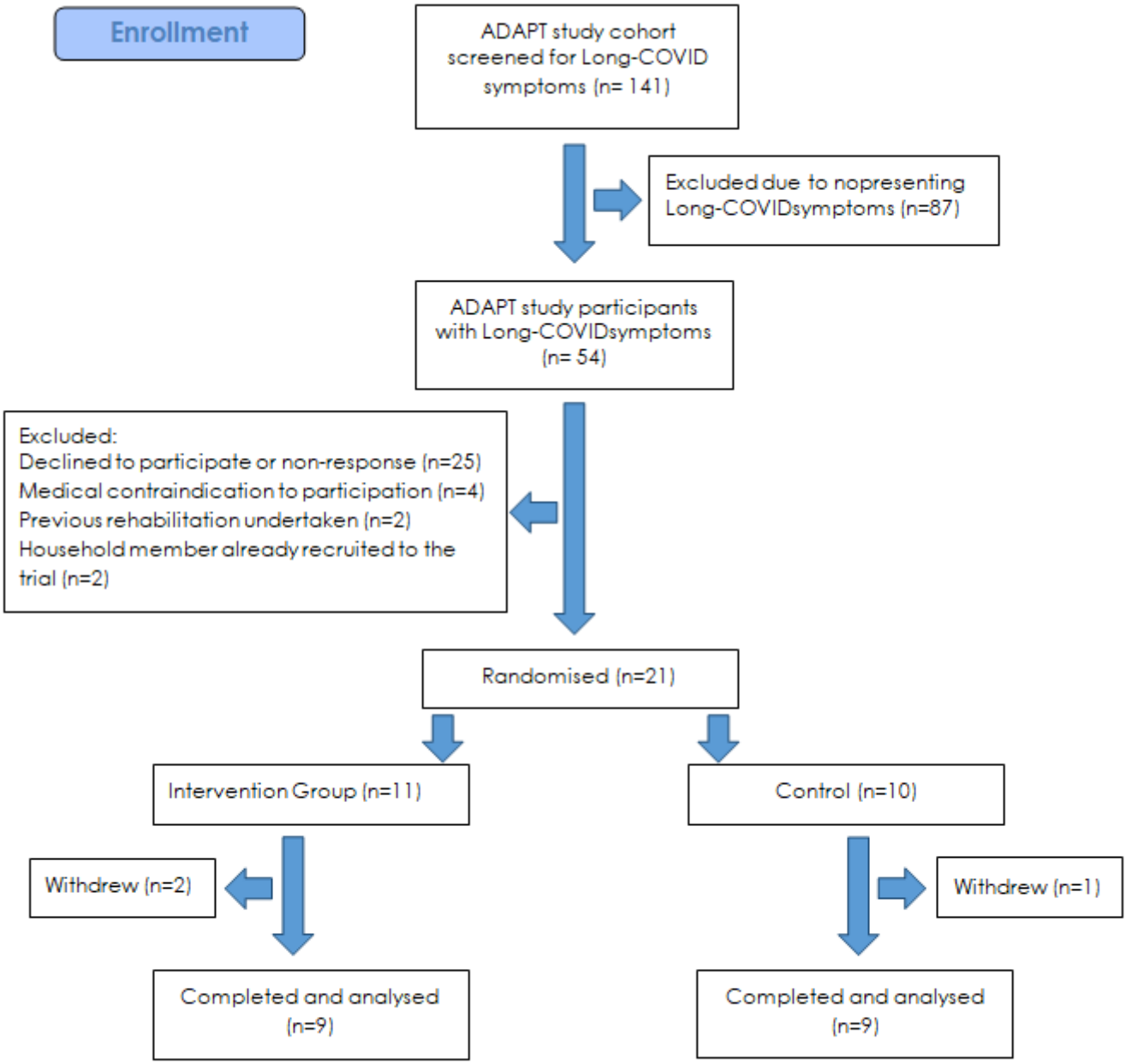

Figure 1

Design and flow of participants through the trial

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