CLINICAL REHABILITATION

The effects of a home-based arm ergometry exercise programme on physical fitness, fatigue and activity in Polio survivors: A randomised controlled trial

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Abstract

Objective: To investigate the effect of an eight-week home-based arm ergometry aerobic exercise programme on physical fitness, fatigue, activity and quality of life in Polio Survivors.

Design: An assessor blinded randomised controlled trial.

Setting: Home-based exercise.

Subjects: Fifty-five Polio survivors randomised to exercise or control groups.

Intervention: Home-based arm ergometry at an intensity of 50%-70% maximum heart rate, compared with usual physiotherapy care.

Main measures: The Six-minute Arm Test, Fatigue Severity Scale, Physical Activity Scale for Individuals with Physical Disabilities and SF-36. Assessments were completed at baseline and at eight weeks.

Results: There was no significant difference in the primary outcome, exercising heart rate during the Six-minute Arm Test, between the groups at follow-up [97.6 (SD10.1) compared to 102.4 (SD13.7) beats per minute (P=0.20)]. Blood pressure was significantly lower in the intervention group at follow-up [systolic blood pressure 132(18.6)mmHg compared to 144.1(14.6)mmHg (P=0.002)]. There were no between group differences in the Fatigue Severity Scale (P=0.25) or Physical Activity Scale for Individuals with Physical Disabilities (P=0.49), with a small difference in SF-36 physical component score (P=0.04).

Conclusions: This home-based arm ergometry programme successfully facilitated aerobic exercise in Polio Survivors, but did not result in a significant change in physical fitness, measured by the Six-minute Arm Test.

Keywords

Late effects of Polio, aerobic exercise, fatigue, home rehabilitation

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Introduction

As survivors of the 20th century Polio epidemics age, many experience pain, orthopaedic complications, fatigue and declining mobility, described broadly as the late-onset sequelae of Polio.[1] Some experience progressive new weakness and are diagnosed with Postpolio Syndrome.[2] Polio survivors walk less and more slowly than healthy people and have low activity levels.[3,4] There is a high prevalence of co-morbidities, which additionally impact on health and quality of life.[5,6] Many of the co-morbidities commonly reported in Polio survivors have significant lifestyle related risk factors, and in addition, high rates of obesity have been reported.[7–10]

It is widely acknowledged that physical activity is essential for good health.[11,12] The American College of Sports Medicine exercise guidelines emphasise that some activity is better than none and advise that people with functional limitations should start with a small amount of activity and build up gradually.[13] A number of aerobic exercise modalities have been investigated in Polio survivors, including walking and treadmill exercise,[14–16] bicycle ergometer exercise,[17–19] arm ergometry[20] and water-based exercise.[21] However, studies investigating aerobic exercise were not included in a recent Cochrane Systematic review as they did not meet inclusion criteria.[22] Consequently, health professionals are limited in their ability to advise Polio survivors to exercise and instead Polio survivors are often advised to decrease activity to manage pain and fatigue.[23] However, reduced activity may be to the detriment of cardiovascular health and contribute to the high rates of co-morbidities. One recent study found that exercise therapy, using a cycle ergometer, did not improve severe fatigue and did not result in an increase in physical fitness.[19] Conversely, a hospital based walking programme did improve fitness in a small group of middle aged Polio survivors,[15] but this approach may not be appropriate for those with pain aggravated by walking.

The American College of Sports Medicine[24] recommend that in this population, stable muscle groups, with adequate strength and without evidence of new progressive weakness, should be utilised for exercise. Arm ergometry is useful in individuals with spinal cord injury[25,26] and may be an appropriate exercise modality for Polio Survivors. One study found a significant increase in maximal oxygen consumption in Polio survivors who completed 16 weeks of aerobic exercise, using arm ergometers in a supervised setting.[20] The impact on variables other than fitness was not assessed and the potential for implementation of such a programme in the community has not been evaluated. Polio survivors report significant barriers to exercise,[27] which include fatigue, pain and decreased mobility. Investigation of affordable, convenient exercise programmes which allow Polio survivors to exercise at home and which are designed to avoid exacerbation of pain and fatigue are required.

The primary aim of this randomised controlled trial was to investigate the effect of an eight-week, home-based, arm ergometry programme on physical fitness. In addition, the impact on activity, pain, fatigue, mobility and health related quality of life were quantified. Finally, compliance with the programme and participant feedback were evaluated.

Methods

A prospective, single assessor blinded, randomised controlled trial was conducted, which evaluated the effectiveness of an eight-week, home-based, arm ergometry aerobic exercise programme on Polio survivors. The trial incorporated two arms (i) an arm ergometry intervention and (ii) control/usual care. It was not possible to blind the treating physiotherapist or the participant to the exercise intervention; therefore a blinded assessor design was utilised. The trial was designed incorporating recommendations of the CONSORT statement.[28] A detailed protocol for the trial was published.[29] The trial was registered on clinicaltrials.gov in January 2011 (NCT01271530). The study was approved by the local Hospital (Medical Research) Ethics Committee in December 2009.

Polio survivors, attending a Post-polio clinic at a tertiary referral centre were considered for inclusion. Inclusion criteria were a confirmed history of Poliomyelitis affecting at least one lower limb, an ability to walk for six minutes, normal upper limb

strength in at least seven out of ten tested movements and aged from 18 to 75. All participants were screened for suitability by a medical doctor using the Physical Activity Readiness Medical Evaluation (PARmed-X),[30] which is a screening tool developed to evaluate medical concerns regarding a new exercise programme, and were deemed medically safe for exercise. Exclusion criteria were any unstable cardiac or respiratory conditions, uncontrolled hypertension, significant upper limb pain, severe fatigue (score greater than five on the Fatigue Severity Scale,[31] a recent onset of upper limb weakness, recent steroid use, medication such as beta blockers and pregnancy. All participants provided written informed consent prior to baseline assessment and were free to withdraw at any time.

Participants were randomly allocated to the exercise intervention or control group. The randomisation sequence was computer generated (www.Randomization.com) and created by a third party not involved in the day to day running of the trial. A 1:1 allocation with block sizes of 10, stratified by gender was employed. Group allocation was performed using sequentially numbered, sealed opaque envelopes. The allocation of participants to either intervention or control groups was concealed from the blinded assessor. Envelopes were opened with the participant by the treating physiotherapist, after the baseline assessment. Participants were reminded by the treating physiotherapist not to disclose their group allocation during follow-up assessment.

All participants received usual physiotherapy care, which included assessment, education regarding activity and fatigue management, pain management, mobility management, including prescription of aids and orthoses and appropriate exercise prescription. Advice regarding appropriate aerobic exercise was provided, but a structured programme or supervised classes were not provided. The control group participants were advised to continue with normal activities and received usual physiotherapy care.

Participants randomised to the intervention group were taught an individualised home exercise programme during a home visit by the treating physiotherapist. Each intervention group participant was provided with a simple, commercially available static cycle, with variable resistance (Online Appendix A), a Polar heart rate monitor and a written exercise programme (Online Appendix B). The static cycle, placed on a table, was used as an arm ergometer, and participants wore the Polar heart rate monitor to allow constant monitoring of heart rate during exercise sessions (Online Appendix A). Participants exercised at a moderate exercise intensity; 50%-70% maximum heart rate and a BORG rate of perceived exertion 13-18,[32] for at least ten minutes three days per week. Duration, intensity and frequency were progressed to a target of 150 minutes of cumulative exercise per week, as recommended by American College of Sports Medicine guidelines.[13] This intensity was considered appropriate as participants were expected to have low activity levels prior to commencing the intervention. Additionally, Polio survivors reach the anaerobic threshold at low levels of exercise intensity (BORG rate of perceived exertion 12).[33] Exercise intensity was modified by changing pedal rate or resistance. An exercise log and instruction booklet were provided at the time of the home visit, and participants recorded exercise intensity and time, as well as symptoms including pain and fatigue (Online Appendix B). Exercising participants were followed up by a minimum of three phone calls over the eight week period where they reported exercise parameters, problems with pain or fatigue and were advised regarding exercise progression.

All assessments were conducted in a standardised format by one of two blinded assessors, each experienced physiotherapists (RV and AC). Demographic data, including information specific to the history of acute Poliomyelitis and mobility were gathered at the baseline assessment. The primary outcome measure and primary endpoint were a change in physical fitness assessed using the Six-minute Arm Test[34] at eight weeks. The Six-minute Arm Test is a sub-maximal exercise test, conducted using an arm ergometer, where heart rate and rate of perceived exertion using the BORG rate of perceived exertion 6-20 scale[32] were recorded at the end of each minute, during six minutes of arm cycling at a predetermined power output, based on

physical ability.[34] The mean heart rate and BORG rate of perceived exertion score from minutes two to six were analysed. The selection of power output levels used in the Six-minute Arm Test were adapted to suit the profile of Polio survivors and reliability of heart rate and the BORG rate of perceived exertion scale were examined in ten Polio survivors.[35] This indicated excellent reliability based on the criteria of Fleiss[36] (HR ICC=0.96, BORG ICC= 0.78), while the smallest real difference was 5.4 beats per minute. In addition to heart rate and BORG measurements, blood pressure was measured at rest, immediately post testing and at three minutes post testing. Secondary outcome measures were selected based on the impairments and activity limitations reported in Polio survivors and using frequently used assessment tools with acceptable validity and reliability (Table 1).[29]

Compliance was evaluated by analysing the number of exercise sessions performed and the exercising heart rate and duration at three timepoints; day two, which was the first exercise session performed independently, day 12 which represented the midway point of the prescribed target of 24 sessions in eight weeks and the final exercise session. An exit questionnaire was developed to evaluate participant feedback after completion of the intervention (Online Appendix C).

The sample size for the study was determined based on a hypothesised change in heart rate of eight beats per minute, during the Six-minute Arm Test. The change in heart rate was based on reported changes in previous exercise interventions and considered clinically significant.[16,18] For the sample size calculation power was set at 80%, alpha at 5% and drop-out rate at 15%. The trial aimed to recruit 120 participants (60 per group).

Data were coded and collated in a Microsoft Excel (2007) spreadsheet. Scoring for each outcome measure was performed based on published scoring protocols. Stata 12 (StataCorp LP) was used for statistical analysis. Analyses were conducted on an intention-to-treat principle.[37] Missing data were managed using the last observation carried forward method, which was considered appropriate as participants were not expected to deteriorate significantly over an eight-week period without the intervention under investigation.[38]

Demographic characteristics and baseline data were summarised using descriptive statistics, but comparability was not statistically analysed in keeping with CONSORT guidelines, as group allocation and therefore any differences were random.[28] Data were examined for normality using the Shapiro Wilk test and visually using histograms. Linear regression modelling was used to compare the differences from baseline to follow-up between the intervention and control groups for each outcome measure. Use of linear regression modelling controlled for any differences between the groups in the baseline values of the outcome measures. Results were reported as the adjusted mean differences between the groups and their confidence intervals. Poisson regression was used where data were not normally distributed. A significance level of $P < 0.05$ was set. The responses on the exit questionnaire were analysed using descriptive statistics and the comments provided in response to open ended questions were assessed qualitatively.

Results

Fifty-five participants were recruited and commenced the trial between January 2010 and April 2013. Participant flow is detailed in Figure 1. The target of 120 participants was not achieved as the three-year time period allocated to the trial had been exceeded. Forty-two females (76%) and thirteen males (24%) took part. The demographic characteristics of the groups are shown in Table 2 and the baseline values of the outcome measures are shown in Tables 3 and 4.

There was no significant difference between the groups, in the primary outcome measure, heart rate during the Six-minute Arm Test, at follow-up (adjusted mean difference, confidence interval of the difference: -2.0 (-5.3,1.4), P=0.20) (Table 3). Blood pressure was significantly lower in the intervention group at follow-up both prior to the exercise test and during recovery (Table 3). Aside from a significant difference in the Physical Component Score of the SF-36[39] there were no statistically significant differences in secondary outcome measures between the groups at follow-up (Table 4).

The intervention group included 26 participants and 16 (62%) completed at least 24 sessions in the

Table 1. Outcome measures used in the trial.

Domain measured	Outcome measure	Variables derived
Physical fitness	The Six-Minute Arm Test[34]	Resting HR (b/min) Exercising HR (b/min) Recovery HR 3 mins post test (b/min) BORG RPE[32] during exercise Pre-testing BP (mmHg) Post testing BP (mmHg) Recovery BP 3 mins post test (mmHg)
Physical activity	The Physical Activity Scale for Individuals with Physical Disabilities questionnaire[45]	PASIPD overall score (MET hr/d)
Mobility	The Six Minute Walking Test (6MWT)[47]	Distance walked (m) Walking heart rate (b/min) Physiological Cost Index (PCI) (b/m)[48]
Fatigue	The Fatigue Severity Scale[31]	FSS score (1-7)
Health related quality of life	The Short Form-36 Health Survey (39)	Physical Component Score (0-100) Mental Component Score Physical Functioning subscale score
Pain	Body charts Visual analogue scales Short Form McGill Pain Questionnaire version 2[49]	Pain location Pain intensity (0-100) Pain intensity and nature (0-10)
Upper limb strength	Quantitative Muscle Assessment (QMA)[50]	Maximum Voluntary Isometric Contraction (kgs) of: Shoulder abduction, Shoulder adduction, Elbow flexion, Elbow extension Hand grip Summed upper limb strength score
Participant opinion	Exit questionnaire (online Appendix C)	Response to the programme
Compliance	Exercise log (online Appendix B)	Number of sessions Exercise heart rate (b/min) Exercise duration (min)

eight week period as prescribed. Four participants completed between 20 and 22 sessions. Three participants discontinued the intervention in the early stages; after two, three and ten sessions and one did not commence the intervention. Compliance data was missing for two participants. The number of sessions completed ranged from zero to 42 sessions in the eight week period, with a mean of 26 (SD 10.4) sessions. The mean recorded heart rate in beats per minute (bpm) and percentage maximum heart rate (HRmax) on session 2 was 97.5 (SD11.3)bpm, 60.2(6.8)%HRMax, on session 12 was 99.6 (SD20.8)bpm, 61.8 (SD 5.6)% HRmax and on the final day was 103.0 (SD11.3)bpm, 63.9 (SD 6.7)%HRmax, indicating that a moderate exercise intensity was achieved. A mean exercise duration of 13.8 (SD 4.1) minutes was recorded on Day 2, 20.8 (SD 5.3) minutes on Day 12 and 22.2 (SD 4.1) minutes was reported at the final session.

Sixteen intervention participants (62%) returned the exit questionnaire (Online Appendix C). The

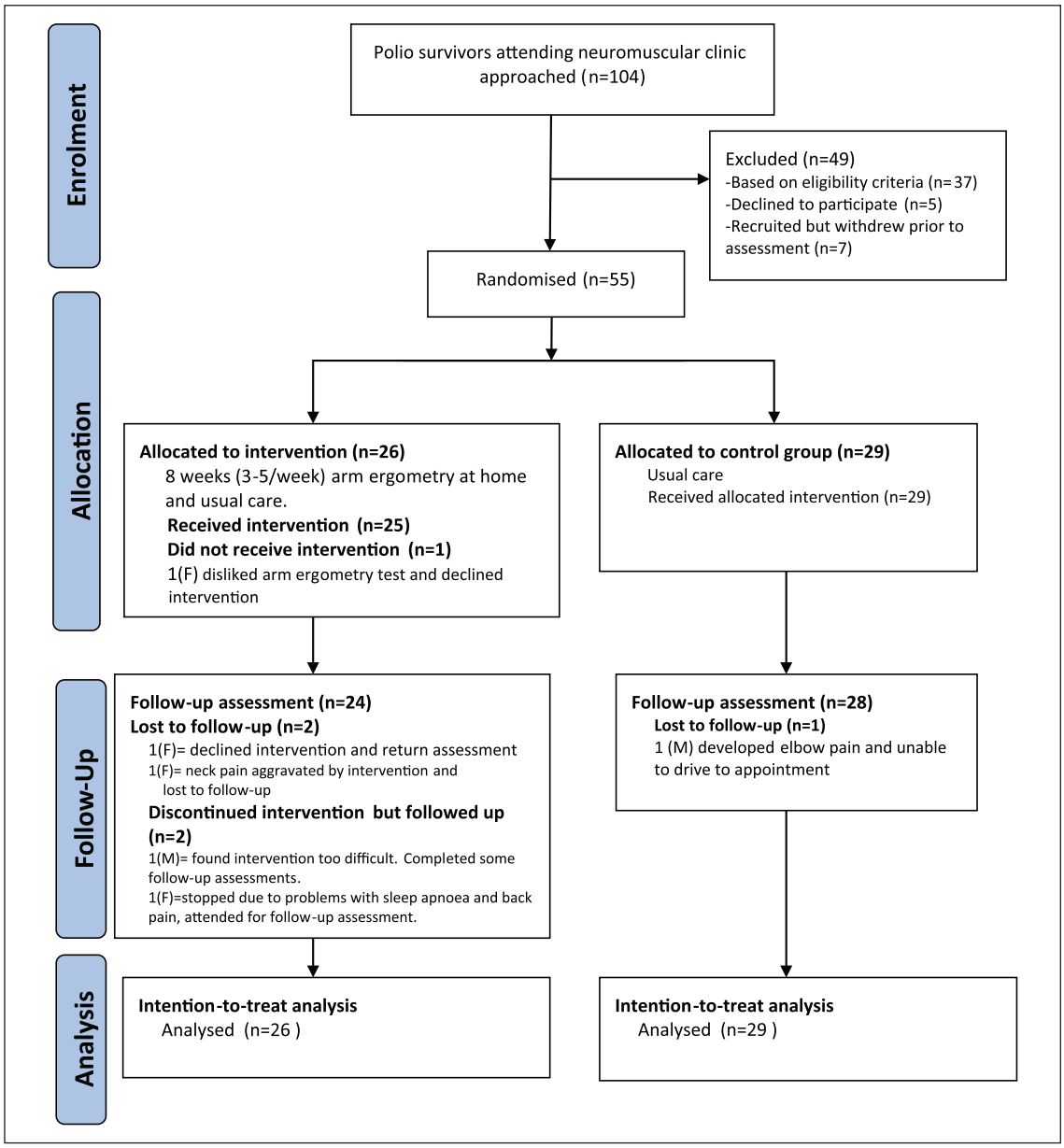

Figure 1. Flow of participants.
F=female, M=male, n=number of participants.

feedback indicated high levels of satisfaction with the study; eight (50%) reported 'great benefit' and six (38%) some benefit. Three participants (19%) expressed difficulty with sticking with the programme as prescribed. Twelve (75%) indicated an intention to continue with the exercise programme.

Table 2. Demographics of the intervention and control group participants.

	Intervention Group *n*=26	Control Group *n*=29
	Mean (SD)	Mean (SD)
Age (years)	59.1 (7.7)	57.8 (8.7)
Height (m)	1.57 (0.81)	1.58 (0.93)
Weight (kg)	71.1 (13.6)	74.4 (14.6)
BMI (kg/m^2)	28.5 (4.5)	29.8 (5.6)
Waist circumference (cm)	92.3 (13.6)	96.0 (11.1)a
Years since acute Polio	56.5 (7.3)	55 (8.4)
	Number (%)	**Number (%)**
Gender = male	5 (19%)	8 (28%)

n = number of participants, a= *n*=28 participants, m=metres, kg=kilogrammes, BMI = Body Mass Index, cm=centimetres, SD=standard deviation.

Discussion

The results of this randomised controlled trial indicated that there was no significant difference between the intervention and control groups in the primary outcome measure; heart rate during the Six-minute Arm Test. Blood pressure was lower in the intervention group at follow-up (Table 3). In addition, no significant differences in pain, fatigue, mobility, activity, or arm strength were identified (Table 4). A statistically significant difference in the Physical Component Score of the SF-36 was identified, which was not clinically significant. Compliance with the programme was very good and the majority of participants subjectively reported that they benefitted from the intervention.

There were a number of limitations to this study, primarily that the sample of 120 participants required based on the power calculation was not reached. Additionally, the use of a submaximal, proxy measure of cardiovascular fitness, the Six-minute Arm Test, using heart rate rather than gas analysis measurement may have resulted in reduced sensitivity to change in fitness. The exercise intensity prescribed may not have been adequately challenging or of long enough duration to produce a clinically meaningful response. A significant change in blood pressure was found, however this was a secondary measure and changes in blood pressure medications was not strictly monitored during the trial.

The primary measure, exercising heart rate, was lower in the intervention group at follow-up (102.4bpm vs 97.6bpm) but the difference between the groups was not significant (P=0.20). This finding may indicate an absence of therapeutic efficacy or may reflect a type II error as the recruitment target was not achieved. In addition, the mean heart rate in the control group also decreased (Table 3), which may reflect the impact of usual care. The duration of the programme was short at eight weeks and a longer duration may have been required to produce a significant change in deconditioned individuals.[13] The duration is similar to that reported by the recent treadmill training study, which reported a positive outcome,[15] but much shorter than previous studies of aerobic exercise training in Polio survivors which reported positive outcomes.[17–21]

The exercise intervention was designed to facilitate exercise at a moderate exercise intensity (50-70% HRmax), three times per week for eight weeks. This was considered appropriate based on the home setting, the sedentary lifestyle and age profile of the Polio survivors and the unfamiliar activity of arm ergometry. Evaluation of the exercise logs indicated that most participants adhered to the exercise prescription and exercised at an intensity of between 61.8 (SD 5.6)% HRmax and 63.9 (SD 6.7)% HRmax, with the majority achieving the prescribed three sessions per week for eight weeks. However, it is possible that this moderate intensity, based on maximum heart rate, was

Table 3. The Six-minute Arm Test at baseline and follow-up; between group comparisons using intention to treat analysis.

Variable		Intervention group (*n*=26)		Control group (*n*=29)		Between group comparison at follow-up	
		Baseline Mean (SD)	Follow-up Mean (SD)	Baseline Mean (SD)	Follow-up Mean (SD)	Adjusted between group diff (CI of diff)	*P*-value[a]
Pre test	**Resting HR b/min**	69.5 (9.6)	68.3 (9.9)	69.9 (10.6)	69.8 (7.2)	–1.3 (–4.5,1.9)	0.40
	Pre-test Systolic BP (mm Hg)	132.2 (19.6)	127.1 (19.2)	132 (14.2)	132.9 (15.7)	–6.0 (–12.8,0.9)	0.09
	Pre-test Diastolic BP (mm Hg)	79.2 (10.4)	76.2 (10.5)	81.6 (9.4)	81.8 (8.8)	–3.9 (–7.5,–0.3)	0.03
During test	**HR during 6-MAT (b/min)**	**101.7 (9.4)**	**97.6 (10.1)**	**105.2 (14.3)**	**102.4 (13.7)**	**–2.0 (–5.3,1.4)**	**0.20**
	BORG RPE	13.9 (1.4)	13.6 (1.9)	13.4 (2.2)	12.6 (2.5)	0.06 (–0.01,0.14)	0.12
	Systolic BP post test (mm Hg)	141 (22.0)	132 (18.6)	141 (14.2)[b]	144.1 (14.6)[b]	–11.8 (–18.9,–4.7)	0.002
	Diastolic BP post test (mm Hg)	73.7 (11.4)	69.5 (10.2)	75.2 (10.1)[b]	75.7 (8.5)[b]	–5.0 (–8.8,–1.2)	0.01
Recovery	**Systolic BP at 3 min (mm Hg)**	129.4 (22.4)	124.7 (15.5)	133 (14.9)	132.4 (15.4)	–5.7 (–12.4,1.1)	0.10
	Diastolic BP at 3 min (mm Hg)	74.4 (10.4)	71.4 (9.2)	76.8 (11.1)	77.1 (10.4)	–4.1 (–7.6,–0.5)	0.03
	HR at 3 min post test (b/min)	76.2 (10.3)	73.3 (9.5)	75.4 (12.1)[b]	74.4 (9.6)	–1.6 (–5.4,2.3)	0.42

n = number of participants, SD = standard deviation, HR=heart rate, b/min = beats per minute, BP = blood pressure, mm Hg = millimetres of mercury, RPE= BORG Rate of Perceived Exertion, 6-MAT= Six-minute Arm Test, HRmax = maximum heart rate, b = data on 2 control group participants missing due to equipment malfunction. *P*-value[a] = derived from linear regression modelling.

Table 4. Secondary outcome measures at baseline and follow-up; between group comparisons using intention to treat analysis.

Variable	Intervention group (*n*=26)		Control group (*n*=29)		Follow-up	
	Baseline Mean (SD)	Follow-up Mean (SD)	Baseline Mean (SD)	Follow-up Mean (SD)	Between group diff (CI of diff)	*P*-value
6MWT, Distance (m)	340.4 (97.2)[25a]	357.3 (91.1)[24a]	319.5 (79.0)	327.5 (80.5)[28a]	12.3 (–4.4,29.0)	0.15
6MWT, Walking HR (b/min)	107.6 (11.6)[25a]	107.7 (11.5)[24a]	112.2 (14.6)	111.1 (13.2)[28a]	–0.41 (–4.3,3.5)	0.83
SF-36 PF	44.6 (24.0)	41.0 (22.8)	46.5 (17.3)	45.3 (21.1)	–2.9 (–9.6,3.9)	0.40
SF-36 PCS	35.7 (9)	36.8 (9.8)	38.8 (8.8)	36.4 (7.2)	2.8 (0.07,5.6)	0.04
SF-36 MCS	53 (8.8)	53.5 (8.9)	48.5 (12.1)	52.6 (9.4)	–0.03 (0.09,0.03)	0.30
Hand Grip Fatigue	24 (9.2)[25b]	23.3 (9.2)[23b]	23.3 (5.9)[18b]	25.7 (8.1)[22b]	–0.9 (–4.5,2.7)	0.61
FSS	4.5 (1.6)	4.2 (1.9)	4.2 (1.5)	4.2 (1.4)	–0.3 (–0.8,0.2)	0.25
UL strength	166.5 (53.4)[24a]	171.6 (47.3)[24a]	180.2 (64.6)[26a]	178.0 (64.9)[26a]	3.6 (–9.6,16.8)	0.59
	Median (IQR)	**Median (IQR)**	**Median (IQR)**	**Median (IQR)**	**Median Diff (CI of diff)**	**p-value[c]**
6MWT, PCI (b/m)	0.72 (0.56,0.87)[25a]	0.67 (0.56,0.77)[24a]	0.78 (0.58,0.99)	0.76 (0.57,0.89)[28a]	–0.08 (–0.21,0.05)	0.22
PASIPD (MET hr/d)	14.1 (6.5,23.6)	13.7 (9.2,21.8)	10.2 (6.1,18.2)	9.6 (5.6,21.2)	0.11 (–0.21,0.44)	0.49
SF-MPQ-2	0.9 (05,1.5)	0.8 (0.3,1.5)	0.7 (0.3,1.2)	0.6 (0.3,1.1)	0.17 (–0.19,0.53)	0.36

n=number of participants, SD=standard deviation, IQR = interquartile range, CI of diff = 95% confidence interval of the difference between the groups, *P*-value[c] = Mann-Whitney U test, 6MWT = Six-Minute Walking Test, PCI=Physiological Cost Index, UL strength = composite score of upper limb Maximum Voluntary Isometric Contraction, PASIPD = The Physical Activity Scale for Individuals with Physical Disabilities questionnaire, measured in MET hours per day (MET hr/d), m=metres, b/min=beats per minute, b/m=beats per metre, a = missing data due to participants who did not complete 6MWT at baseline and/or follow-up, numbers included in analysis shown in superscript, b = missing data on hand grip static fatigue at both time-points due to equipment malfunction and clerical omission.

inadequate to produce a clinically meaningful change. In addition, the progression of the programme was not formally structured and may have yielded a greater effect with a structured progression, potentially with weekly heart rate and exercise time targets. Arm ergometry utilises the smaller arm muscles and therefore is inherently limited in its ability to stimulate aerobic activity compared with other forms of exercise such as walking or cycling, which use the larger leg muscles. In addition, exercise time can be limited by muscle rather than cardiovascular factors[40] and the mean duration of exercise at the final session of 22.2 (SD 4.1) minutes, may have been limited by muscle fatigue.

The Six-minute Arm Test may not have been sufficiently sensitive to detect a clinically significant change. Submaximal exercising testing has been recommended for Polio survivors,[24] and the Six-minute Arm Test was selected as a submaximal test suitable for assessment of the arm ergometry intervention. However, studies in Polio survivors, which have used submaximal protocols have failed to identify significant changes in fitness.[16,19] Studies using graded maximal tests analysing oxygen consumption (VO_2 max) and heart rate have identified significant changes post exercise, although there are limitations in the design of these studies limiting interpretation.[17,18,20] The gold standard measure of cardiopulmonary fitness is the measurement of VO_2 max and the correlation between this and the Six-minute Arm Test is moderate.[34] The Six-minute Arm Test was developed for use in spinal cord injury patients[34] and the evaluation of its sensitivity to detect changes in fitness has not been reported to date.

Blood pressure was recorded before and after the Six-minute Arm Test as a secondary element of the assessment. A significant between group difference, in favour of the intervention group, in resting diastolic blood pressure of 3.9mmHg (adjusted 95% CI: -7.5,-0.3) was found at follow-up (P=0.03). The intervention group also had significantly lower blood pressure immediately post exercise and in the recovery period (Table 3), which may suggest an improved cardiovascular response to exercise. Prehypertension is primarily managed with lifestyle modification, including physical activity[41] and this intervention provided an accessible form of exercise for participants. Post-hoc analysis indicated that the percentage of participants in a pre-hypertension category reduced from 42% to 27% in the intervention group, with a corresponding increase in those categorised as having normal blood pressure. All participants were medically cleared to exercise prior to the study, but changes in blood pressure medications were not recorded during the study. No changes in blood pressure categories were seen in the control group.[35] Most studies examining aerobic exercise in Polio survivors have not reported blood pressure,[15,16,18,19,21] limiting comparison. The only previous study examining arm ergometry found no changes in systolic or diastolic blood pressure after the intervention,[20] while one study examining a 16-week programme of bicycle ergometry reported a similar decrease of 4.7 mmHg in systolic blood pressure.[17] Changes in blood pressure and cardiovascular health with exercise interventions require targeted investigation in this population.

The problems reported by Polio survivors include fatigue, weakness, pain, decreased mobility and activity limitation.[2,42] There has been concern that exercise may overload weak muscles and result in further deterioration, however this had not been systematically addressed in previous studies.[15,17,21] Therefore, evaluation of the effect of the intervention on upper limb muscle strength, pain and fatigue was required.[43,44] No significant differences between the groups were identified (Table 4), indicating an absence of adverse effects of this exercise intervention.

There was a statistically significant difference between the groups in the Physical Component Score of the SF-36 (P=0.04), but this was not considered clinically meaningful (Table 4). The absence of a difference in activity levels, as reported in the Physical Activity Scale for Individuals with Physical Disabilities,[45] is surprising as those participants in the intervention group recorded approximately 60 additional minutes of activity per week in the exercise logs. The Physical Activity Scale for Individuals with Physical Disabilities was chosen as it was developed specifically for individuals with a disability, but the validity of the measure has been questioned since this study commenced.[46]

This study found that a home based arm-ergometry aerobic exercise intervention was well tolerated in Polio survivors, but did not improve physical fitness, fatigue, or activity. Changes in blood pressure in the exercise group require confirmation in future studies. This study provides a basis for further investigation of modified training programmes examining whether Polio survivors can access the health benefits associated with exercise in the long term.

Clinical Messages

- Home-based arm ergometry facilitated moderate intensity aerobic exercise in Polio survivors.
- A significant reduction in blood pressure suggested improved cardiovascular health.
- Secondary outcomes including mobility, fatigue, activity and quality of life did not change.
- There was no evidence of increased fatigue or loss of muscle strength in the arms.

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