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ORIGINAL RESEARCH

Integrating Survivors of Stroke Into Exercise-Based Cardiac Rehabilitation Improves Endurance and Functional Strength

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BACKGROUND: Cardiac rehabilitation (CR) is a structured exercise program prevalent in the United States for people with cardiovascular disease that has been shown to increase cardiovascular endurance and improve quality of life. Despite similar cardiovascular risk factors, stroke is not among the covered diagnoses for CR. The purpose of this study was to examine the participant impact of integrating survivors of stroke into the exercise portion of an existing hospital-based CR program through measures of physical function and other health impacts and through qualitative evaluation of participant perception.

METHODS AND RESULTS: Subacute and chronic survivors of stroke were integrated into a standard 12-week, 3 sessions per week, exercise-based CR program. A total of 29 began the program, 24 completed the program, and 18 were available for 6-month follow-up. Quantitative measures were compared preprogram with postprogram with *t*-test or equivalent, and preprogram with postprogram to 6-month follow-up with ANOVA or equivalent. Semistructured interviews were completed with 11 participants postprogram. Exercise-based CR had significant impacts on cardiovascular endurance preprogram to postprogram, with maintenance at 6-month follow-up. The participants improved on the 6-minute walk test on average by 61.92 m(95% CI, 33.99–89.84 m), and maximum metabolic equivalents improved by a median of 3.6 (interquartile range, 2.35). Five times sit to stand (functional strength) improved preprogram to postprogram by a median of 2.85 s (interquartile range, 4.03 s). Qualitative findings highlight additional health improvements. Most participants (83% [15/18]) reported continued exercise at follow-up.

CONCLUSIONS: Exercise-based CR has the potential to improve cardiovascular endurance, health status, and quality of life for survivors of stroke.

REGISTRATION: URL: https://www.clinicaltrials.gov; Unique identifier: NCT03706105.

Key Words: cardiac rehabilitation ■ exercise ■ stroke ■ stroke rehabilitation

Physical inactivity is a health concern for most of the 7 million survivors of stroke in the United States who face increased risk for additional stroke and cardiovascular disease.[1] Exercise can mitigate these risks, but survivors of stroke are not exercising; 58% fail to meet stroke guidelines for physical activity (PA).[2,3] Although many survivors of stroke receive physical therapy immediately post-stroke, time barriers and an emphasis on functional activities limit cardiovascular exercise intervention.[4,5] As a result, survivors remain deconditioned after traditional rehabilitation, when they transition from one-on-one care with a physical therapist to self-directed individual activity.[6,7] The lack of appropriate

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CLINICAL PERSPECTIVE

What Is New?

- Including survivors of stroke into exercise-based cardiac rehabilitation is an innovative way to reach an additional clinical population at risk for cardiovascular complications with structured exercise.
- The current study demonstrates that the dosage and intensity of exercise-based cardiac rehabilitation have the potential to improve cardiovascular endurance, health status, and quality of life, with some improvements persisting after 6 months.

What Are the Clinical Implications?

- Medical and rehabilitation providers could have a new referral option to a standardized program shown to improve cardiovascular endurance, health status, and quality of life for survivors of stroke.
- Currently, there are no standardized exercise programs for people poststroke, so survivors are left to manage their activity on their own.
- Many survivors of stroke face barriers and are generally inactive. Exercise-based cardiac rehabilitation would provide an option for survivors over self-management.

Nonstandard Abbreviations and Acronyms

6MWT	6-minute walk test
CR	cardiac rehabilitation
PA	physical activity
RPE	rating of perceived exertion
SIS	Stroke Impact Scale

community group exercise programs impedes continuation of supervised PA.[8] Without guidance or knowledge on appropriate activity, most survivors of stroke do not continue to exercise or engage in PA postrehabilitation.[9–11] In addition to deconditioning and risk factor reduction, exercise may positively impact poststroke depression, fatigue, and community participation.[12–14]

Structured exercise programs offer an opportunity to break the cycle of inactivity, reduce future cardiac risk, and improve perceived confidence and quality of life.[13–15] In the United States, cardiac rehabilitation (CR) is a structured and prevalent exercise program for people with cardiovascular diagnoses, such as myocardial infarction.[16] Participation in CR has been shown to increase functional exercise capacity and improve perceived health-related quality of life for traditional participants.[17–19] Previous studies of cardiovascular training in survivors of stroke have demonstrated that they can safely perform aerobic exercise and achieve health benefits.[20–26] Variation in dosage, staffing, and mode of activity impacts the external validity of these studies[20–26]; therefore, more knowledge is required to determine if benefits translate into existing CR programs. Research in Canada suggests the potential for integration of survivors of stroke into existing CR programs; however, the dosage and insurance climate differ from US programs.[27–29] Effectiveness in existing CR programs for survivors of stroke in the United States that follow Medicare guidelines has not been investigated. Evaluation of these programs is supported by the American Heart Association and the American Stroke Association.[14]

The primary aim of this study was to investigate the impact of an existing CR program for survivors of stroke through pilot measures for physical function (cardiovascular endurance, functional strength, and walking speed) and for other health impacts (quality of life, balance confidence, depression, and exercise habits). A secondary aim was to evaluate participant perception of program impact on physical function, health, and future exercise plans.

METHODS

The study was conducted at multihospital health system's CR facility, located in the southeast United States. A mixed methods design combined a single group, preprogram-postprogram design, with a pragmatic qualitative inquiry of participant perception to enhance interpretation of results. All data and materials have been made publicly available at Open Science Framework.[30]

The project was approved by the health system Institutional Review Board and acknowledged by the University of South Carolina Institutional Review Board. The study was a registered clinical trial through the US National Library of Medicine (ClinicalTrials.gov identifier: NCT03706105). Participation was voluntary, and individuals were able to opt out at any time. The program was free for study participants, with program costs ($237 per participant) covered by study grant funding. Participants provided informed consent and an authorization for use and disclosure of protected health information for research purposes.

Recruiting and Study Criteria

Potential participants were recruited from health system rehabilitation clinicians, physicians, stroke team

nurses, and CR providers. In addition, survivors of stroke were recruited directly from the community through stroke support groups and word-of-mouth referrals. Multiple referral targets were chosen to reflect likely general community program sources. Those who were interested were screened for eligibility by primary investigator (Figure 1).

The following inclusion criteria were applied: (1) diagnosed with most recent stroke at least 3 months prior (stroke diagnosis code and date provided on physician referral; multiple stroke occurrences allowed); (2) completed physical and occupational therapy, if applicable; (3) cleared by treating physician or nurse practitioner to participate; (4) demonstrated ability to walk at least 40 m with or without an assistive device; (5) demonstrated ability to transfer from sit to stand without assistance; and (6) demonstrated ability to follow instructions and to communicate exertion, pain, and distress. Potential participants were excluded from the study for any of the following: (1) presence of a medical problem rendering exercise unsafe; (2) complaints of significant pain that interfered with movement; or (3) history of an additional, nonstroke, neurologic condition.

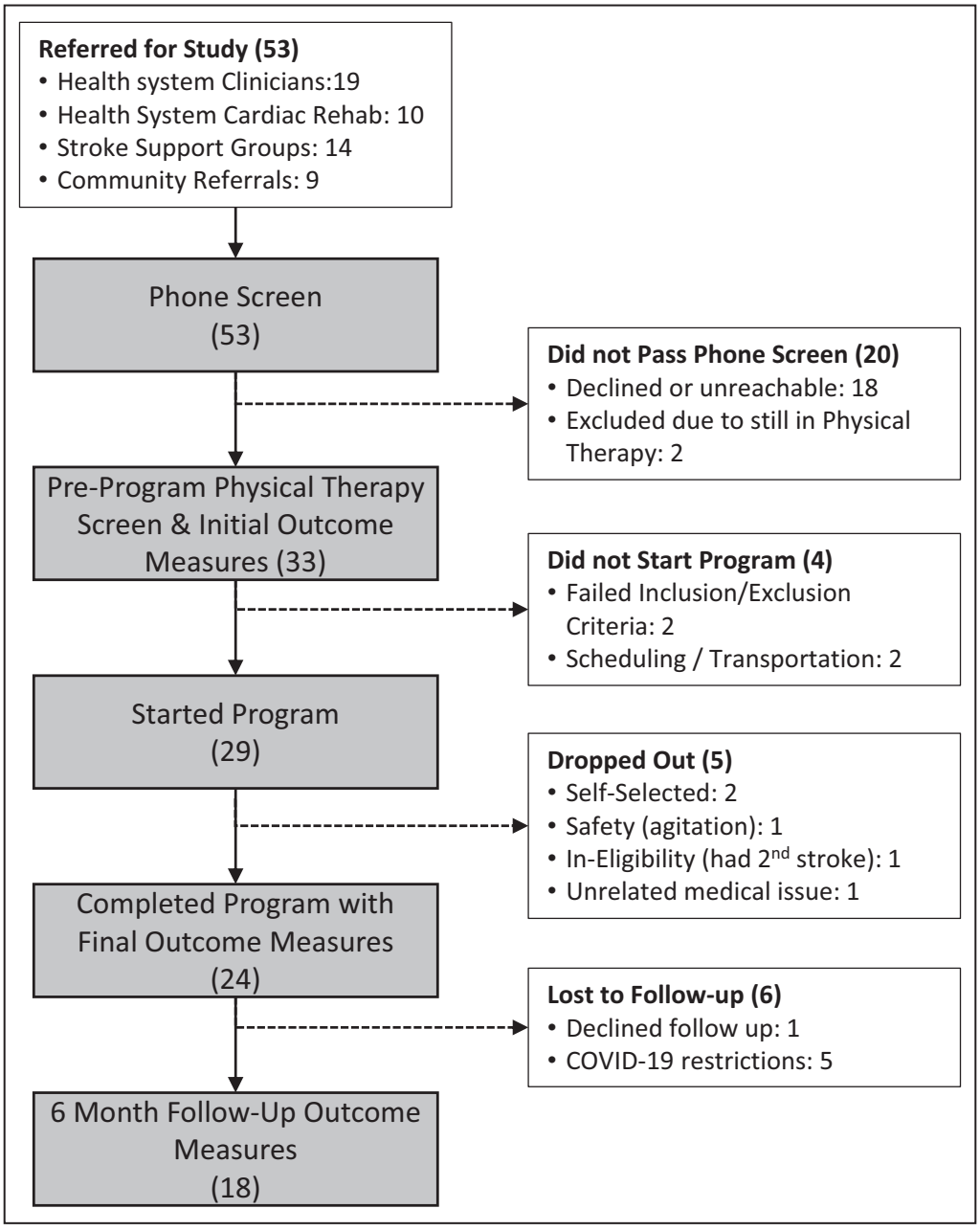

Figure 1. Study flowchart.
COVID-19 indicates coronavirus disease 2019; Phone, telephone; and Rehab, rehabilitation.

Once eligibility was determined, the primary investigator (a physical therapist) screened participants for safety, and participants completed a demographic intake form and a battery of outcome measures. Screening (one-time mobility assessment at preprogram only) assessed range of motion, strength, balance limitations, and gait alterations. Initial determination of safety to participate was determined medically by the referring physician and from an independent mobility perspective by the study primary investigator.

Program Procedures and Progression

The mobility screening measures and the preprogram outcome measures were shared with the CR staff to establish initial exercise intensity goals and modifications to the standard CR exercise program. Participants were integrated into the standard CR exercise program. Aside from modifications provided by the participant evaluation, the exercise intervention did not differ from the standardized program. The program began with analysis to determine baseline levels of exercise intensity in metabolic equivalent tasks (METs) based on participant's 6-minute walk test (6MWT) results. Target heart rate was estimated from resting heart rate and 6MWT completion heart rate. Target exercise rating of perceived exertion (RPE) levels were set from 11 to 14 (somewhat hard to hard) on a scale of 6 to 20.[31] Activity plans were also individualized. Training sessions were 3 times a week for 12 weeks, with a target of 31 to 50 minutes of moderate aerobic activity each session. Additional optional activities included strengthening, stretching, and/or relaxation. Although components varied by session and individual, the general format was warm-up, cardiovascular endurance activities (treadmill, recumbent step machine, recumbent bike, and over ground walking), cooldown, and optional activities.

Progression in the program was determined by participant-reported RPE. If RPE was consistently rated ≤11, effort was increased to reach a rate of 14. Discontinuation of a session or the program was determined by standard health system protocols (Data S1).

Weekly formal educational sessions were not adapted for survivors of stroke. Sessions were available to survivors of stroke but were not used. Medical evaluation and monitoring for heart rate, blood pressure, heart rhythms, and blood glucose were completed on the basis of protocols and clinical expertise of supervising nurses and exercise physiologists. Providers educated participants informally on self-monitoring, home exercise, diet, and nutrition during exercise sessions and recorded education in daily notes.

At the end of the 12-week CR exercise program, all participants were reassessed using the study outcome measures and an additional inquiry of participant's postprogram exercise plans. Completion of the program included all participants with final outcome measures available at postprogram assessment.[32]

Six months after the end of the CR exercise program (follow-up), program completers were invited to return for the last outcome measure assessment, which included an additional self-report of current exercise habits.

Outcome Measures

Study primary investigator administered outcome measures preprogram, postprogram, and 6 months postprogram (Table 1 and Table S1). Maximum METs are a standard measure of exercise tolerance and functional capacity in CR programs.[33] All remaining outcome measures have been validated in survivors of stroke.[34–43]

Statistical Analysis

Power analysis was conducted on the basis of findings from a previous study with a similar population and exercise intervention.[44] Calculations suggested

Table 1. Outcome Measures

Outcome Measure	Assessment
6-min Walk test	• Cardiovascular endurance; walking capacity; initial fitness in CR programs[18,34] • Measured as distance in meters
5 Times sit to stand test	• Functional lower body strength[38,41] • Measured as seconds to complete
10-m Walk test	• Self-selected and fast walking speed[34,42] • Measured as m/s
Maximum METs*	• Standard measure of exercise tolerance and functional capacity in CR programs[33] • Measured from 1 (very low) to 13 (very high) fitness
Activities-Specific Balance Confidence Scale	• Self-perception of balance confidence[37] • Total score, 0%–100% confidence • A score <67% indicates an increased risk of falls[43]
Stroke Impact Scale	• Impact of stroke on 8 domains: mobility, participation, activities of daily living, hand function, strength, communication, emotion, and memory/thinking[35] • Domain subscores from 0% (significant impact) to 100% (no impact)
Short Self-Efficacy for Exercise and Short Outcome Expectations for Exercise Scales	• Confidence to complete exercise behaviors, such as exercising alone or through fatigue[39] • Exercise outcome expectations, such as belief that exercise improves mood or improves endurance[39] • Scores are from 1 (low) to 5 (high)
Patient Health Questionnaire-9	• Depression[40] • Total score of 0–27, with categories of 0 (no depression), 1–9 (minimum to mild depression), 10–14 (moderate depression), and 15–27 (moderately severe to severe depression)

CR indicates cardiac rehabilitation; and MET, metabolic equivalent task.
*Maximum METs were calculated at the initial visit and final visits as part of the standard program and were not reassessed at 6-month follow-up.

22 participants would provide 80% power to detect preprogram-postprogram changes moderate in magnitude (effect size d=0.56) in the 6MWT.

Participant demographic information and outcome measures were aggregated, with means, medians, and SDs calculated. Aggregate means and SDs for total number of sessions, session time, and minimum and maximum RPE were calculated for fidelity of the program to contextualize outcome measure results. The outcome measure data for the full sample of completers preprogram-postprogram (n=24) were analyzed using a paired *t*-test or Wilcoxon signed rank test (for those not normally distributed or ordinal variables). The α level was set at 0.01 because of multiple comparisons and the desire to minimize both type I and type II errors.[45] Effect sizes (Cohen d values) were generated. Finally, for the subset of the sample in whom 6-month follow-up data were available (n=18), a repeated measures ANOVA or a Friedman test was completed for those measures found to be statistically different in the preprogram-postprogram comparison. Bonferroni adjustments were made to the ANOVA and Friedman tests. Analysis was completed with IBM SPSS Statistics for Windows, version 26 (IBM Corp, Armonk, NY).

Qualitative Methods and Analysis

A pragmatic qualitative approach evaluated participant perspectives on program outcomes and future exercise plans.[46,47] Interview questions were developed on the basis of study aims and framed by the World Health Organization's International Classification of Function and Social Cognitive Theory.[48,49] The interview guide is provided in Table S2.

The sampling plan was nested within the original sample, and potential qualitative participants were identified sequentially as they completed the program. All participants who began the program and met qualitative eligibility requirements were invited to voluntarily participate. Participants who had previously participated in CR or had verbal communication limitations were ineligible for the qualitative portion. Participants in the qualitative portion of the study provided separate informed consent and received a $20 gift card as an incentive. Semistructured interviews were conducted in a private room at the time of postprogram outcome measure collection. Interviews were audio recorded and transcribed verbatim. Questions were piloted in the first 2 interviews and revised slightly. The number of participant interviews was determined by maximal voluntary participation of those eligible to achieve saturation of themes.[50] Field notes and addition of quantitative data added rigor.[51]

The researchers completed inductive thematic analysis using NVivo software version 12 (QSR International),[52] with deidentified transcripts and observation notes. One researcher coded all interviews to phrases or sentences directly from the transcripts and structured observations. Results were reviewed with a second researcher. Both researchers then independently performed inductive categorization of the open coding. A final thematic codebook was agreed on. Each researcher updated independent coding to reflect the codebook. Data conflicting with primary themes were identified to present alternative viewpoints.[52] Results were compared, and any discrepancies were resolved together. Final coding was reviewed with a third researcher, where naming conventions and minor alterations were made.

RESULTS

Study referrals began in August 2018, with active program participation through November 2019 and 6-month follow-ups through February 2020. Of the 29 participants starting the program, there were 24 completers. Of the 5 noncompleters, 2 dropped out, 1 was unable to be independent because of agitation/cognitive issues, 1 had an additional mild stroke and no longer met the inclusion criteria, and 1 had recurrent bronchitis. Of the 24 completers, 18 returned for 6-month follow-up assessments (Figure 1). Six completers were lost to follow-up: 1 declined, and 5 were impacted by coronavirus disease 2019 facility closure. Of the 13 eligible completers, 11 participated in the qualitative interviews.

Program participant demographics are presented in Table 2. The most common comorbid health conditions included high blood pressure (83.3%), diabetes mellitus (41.7%), cardiovascular disease (41.7%), and arthritis (29.2%). Completers time since stroke varied, with 38% (9) <1 year poststroke and 62% (15) ≥1 year poststroke. Of completers, 29% (7) reported a history of multiple strokes. In addition, 29% (7) of completers previously participated in CR for a traditional cardiac diagnosis. The average number of sessions per completer was 25.25 (95% CI, 22.91–27.92), with a range of 12 to 36 sessions. Completers averaged 38.93 (95% CI, 36.54–41.31) exercise minutes per session and met RPE targets of 11 (light) to 14 (somewhat hard), with minimum RPE median of 11 (interquartile range, 0.625) and maximum RPE median of 13 (interquartile range, 1.00) across all sessions. There were no safety events related to exercise intensity, and all participants met the prescribed RPE ranges.

Results of preprogram to postprogram comparisons are presented in Tables 3 and 4,[53,54] and results for preprogram, postprogram, and 6-month postprogram comparisons are presented in Figure 2. Outcomes and qualitative themes are presented for the following: (1) cardiovascular endurance, (2) other physical outcomes and general health, (3) emotional health, (4) exercise self-efficacy and outcomes expectations, and (5) postprogram exercise.

Table 2. Demographics of Program Participants

Variable	Completers (n=24)	Noncompleters (n=5)
Sex, % (n)		
Men	79 (19)	60 (3)
Women	21 (5)	40 (2)
Age, mean (SD), y	62.2 (12.4)	68.4 (15.0)
Race/ethnicity, % (n)		
White	71 (17)	60 (3)
Black	25 (6)	40 (2)
Asian	4 (1)	
Type of stroke, % (n)*		
Ischemic	65 (15)	40 (2)
Hemorrhagic	12.5 (3)	40 (2)
Unknown	25 (6)	20 (1)
Time since stroke, mean (SD), mo	29.7 (29.9)	37.0 (41.8)
Initial 6MWT distance category, % (n)†		
≥288 m	83.3 (20)	40 (2)
<288 m	16.7 (4)	40 (2)
No 6MWT		20 (1)
Initial SSWS, mean (SD), m/s	1.17 (0.21)	0.67 (0.28)
Preprogram exercise level, % (n)		
None	12.5 (3)	40 (2)
<1× wk	12.5 (3)	0 (0)
1–3× wk	37.5 (9)	60 (3)
>3× wk	37.5 (9)	0 (0)

6MWT indicates 6-minute walk test; and SSWS, self-selected walking speed.
*Stroke type was self-reported by participant.
†The 6MWT ≥288 m indicates community ambulator status.[42]

Cardiovascular Endurance

The 6MWT, the Stroke Impact Scale (SIS)-Mobility subscale, and maximum METs measured cardiovascular endurance. The 6MWT, the primary outcome measure for aerobic and walking capacity, improved by 61.92 m (95% CI, 33.99–89.84 m) preprogram-postprogram, with a large effect size (0.94), which is greater than the minimal detectable change of 34 m for survivors of stroke (Table 3).[34,55] Improvements in 6MWT distances were maintained at 6-month follow-up results (Figure 2A).

The SIS-Mobility subscale had a statistically significant median improvement postprogram of 6.94%, which is greater than the clinically important difference of 4.5% (Table 4).[53] However, comparisons including the 6-month follow-up did not find a statistically different change over time (P=0.057).

Maximum METs progressed with a median difference of 3.6 (interquartile range, 2.35) from the beginning of the program (first session) to the end of the program (final session at week 12) (Table 4).

Qualitative themes related to endurance included improved stamina, improved stair climbing, and needing less rest breaks during activity. For some, improved endurance impacted their PA tolerance, and they were able to do more of what they enjoy.

> *Participant 11: "I think that, because of improving my stamina and my endurance, that has um, helped me in other things. So, um it, it's allowed me to do a little bit more dancing, and a little bit and, and not have to constantly be resting as much … "*

> *Participant 15: "Um, yes it's … think … just walking and uh, uh just general um physical activities and I think … I don't wanna over say it, it but ah I have to think that, ah, it's improved my every day, ah, activity tolerance."*

Other Physical and General Health Outcomes

Other physical outcome measures included strength, walking speed, stability and balance, and general health impacts. The 5 times sit to stand test measured lower extremity strength, which improved by a median of 2.85 s (interquartile range, 4.03 s) (Table 4). The 5 times sit to stand test gains remained at 6-month follow-up (Figure 2B).[54] Participants maintained but did not improve their walking speed, Activities-Specific Balance Confidence Scale score, or SIS-Physical subscale score preprogram to postprogram. The

Table 3. Results Preprogram to Postprogram: Paired *t*-Test Outcome Measures

Test	No.	Proprogram, Mean (SD)	Postprogram, Mean (SD)	Change, Mean (SD)	95% CI of Mean Change	t	df	Significance (P Value)	Effect Size (d)
6MWT, m*	24	397.80 (119.23)	459.71 (118.46)	↑ 61.92 (66.13)†	33.99–89.84	4.587	23	<0.001‡	0.94
FWS, m/s§	23	1.50 (0.42)	1.59 (0.50)	↑ 0.09 (0.18)	0.02–0.17	3.167	22	0.019	

6MWT indicates 6-minute walk test; and FWS, fast walking speed.
*Higher distance indicates an improvement in score.
†Greater than the minimal detectable change for stroke of 31 m.[34]
‡Statistically significant changes.
§Higher number indicates a faster walking speed.

Table 4. Results Preprogram to Postprogram: Wilcoxon Signed Rank Test Outcome Measures

Test	No.	Preprogam, Median (IQR)	Postprogram, Median (IQR)	Change, Median (IQR)*	Z	Significance (P Value)
Cardiovascular endurance measures						
SIS-Mobility (0%–100%)	24	72.22 (31.25)	77.78 (29.17)	↑ 6.94 (11.11)†	2.665	0.008‡
MET maximum (1 [low] to 13 [high])	24	2.95 (0.88)	6.00 (3.00)	↑ 3.6 (2.35)	4.199	<0.001‡
Physical function measures						
FTSS test, s (lower score is better)	23	14.42 (11.14)	12.2 (6.47)	↓ 2.85 (4.03)§	–3.528	<0.001‡
SSWS, m/s (higher score is faster)	23	1.16 (0.34)	1.18 (0.38)	↑ 0.02 (0.16)	1.095	0.274
ABC Scale score, % confidence	24	73.44 (35.28)	86.38 (21.48)	↑ 1.78 (14.61)	1.686	0.092
SIS-Physical (0%–100%)	24	62.50 (37.50)	75.00 (37.50)	– 0.00 (18.75)	1.350	0.177
Quality-of-life measures (SIS-Other subscales)						
SIS-Mood (0%–100%)	24	77.78 (29.17)	86.11 (20.14)	↑ 4.17 (13.19)	1.869	0.062
SIS-Memory (0%–100%)	24	78.57 (37.50)	82.14 (27.68)	– 0.00 (16.96)	2.076	0.038
SIS-Communication (0%–100%)	24	87.50 (50.00)	83.93 (31.25)	– 0.00 (13.39)	1.623	0.105
SIS-ADL (0%–100%)‖	24	90.00 (31.25)	90.00 (16.90)	↑ 2.50 (9.38)	2.425	0.013
SIS-Hand (0%–100%)	24	85.00 (43.75)	92.50 (40.00)	– 0.00 (10.00)	1.002	0.316
SIS-Participation (0%–100%)	24	70.31 (53.91)	76.56 (39.06)	↑ 3.13 (21.09)	1.976	0.048
SIS-Recovery (0%–100%)	24	80.00 (15.00)	82.50 (15.00)	↑ 5.00 (10.00)	1.715	0.086
Self-efficacy measures (exercise and outcome expectations)						
SSEE Scale (1 [low] to 5 [high])	22	4.20 (1.19)	4.50 (0.69)	↑ 0.25 (1.06)	2.023	0.043
SOEE Scale (1 [low] to 5 [high])	22	4.00 (0.60)	4.20 (1.60)	↑ 0.20 (0.65)	2.397	0.017

ABC indicates Activities-Specific Balance Confidence; ADL, activities of daily living; FTSS, 5 times sit to stand; IQR, interquartile range; MET, metabolic equivalent task; SIS, Stroke Impact Scale; SOEE, Short Outcome Expectations for Exercise; SSEE, Short Self-Efficacy for Exercise; and SSWS, self-selected walking speed.

*↑ Indicates improvement, ↓ indicates decline, and – indicates no change.

†Change is greater than the clinically important difference rate of 4.5%.[53]

‡Statistically significant changes <0.01.

§Change is greater than the 1.14-s minimal detectable change for survivors of stroke.[54]

‖SIS-ADL change score distribution was not symmetrical, so a sign test was completed instead of Wilcoxon signed rank test.

proportion of participants in the highest fall risk category (Activities-Specific Balance Confidence Scale score, <67%) was 33.3% (n=8) preprogram and 20.8% (n=5) postprogram. A few participants noticed balance improvements, with qualitative themes noting improved reaction times and better balance confidence. Several participants noted improvements in their walking, often related to improved stability, balance, and strength.

> *Participant 18: "My reflexes are getting quicker. I can, I can look both ways quicker on the crosswalk, and I can run across the street and I can read the car coming at me quicker."*

General health outcome measures included the remaining Stroke Impact Scale subscales (SIS-Activities of Daily Living, SIS-Hand, SIS-Communication, SIS-Memory, SIS-Participation, and SIS-Recovery [overall self-rated stroke recovery]), all without statistically significant changes. A few participants noted health changes not covered above; themes included weight loss/improved physical appearance, positive medication changes, and improved awareness of importance of health.

> *Participant 3: "… I have been thinking about my health and how to live the best life that I can and I think this program has encouraged this thinking on my part."*
>
> *Interviewer: "Okay, and what are you thinking you need to do to live the best life? Like are you thinking about changes you need to make?"*
>
> *Participant 3: "Well I got a referral for speech therapy and I am doing that now, and I am not sure that would have occurred to me before. And um I think the eating has been better."*

Emotional Health

Several study outcomes measured emotional health: the Patient Health Questionnaire-9, the SIS-Mood subscale, and an analysis of qualitative interviews. The SIS-Mood subscale did not have statistically significant

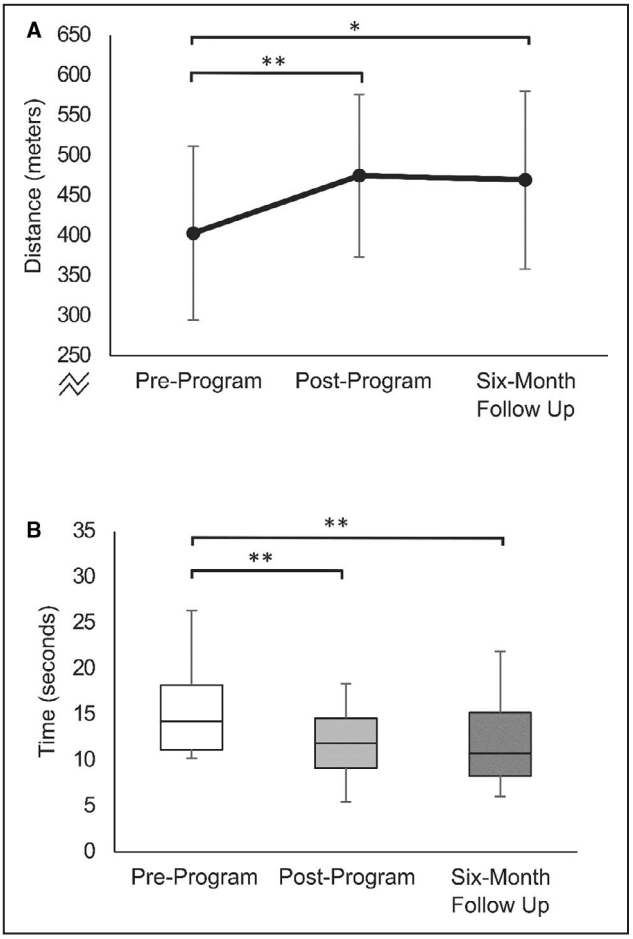

Figure 2. Changes over time.
A, Improvements over time in mean 6-minute walk test (6MWT) distance, ANOVA, n=18 (P=0.001), effect size 0.41. *Indicates 66.51-m change (95% CI, 12.80–120.24 m): P=0.013. **Indicates 71.67-m change (95% CI, 26.19–117.15 m): P=0.002. 6MWT distance mean (SD) preprogram, 403.18 m (108.34 m); postprogram, 474.85 m (101.49 m); and 6-month follow-up, 469.70 m (26.17 m). Error bars are SD. **B**, Improvements over time in the 5 times sit to stand (FTSS) test time in pairwise comparisons, Friedman test, n=17 (P<0.001). Faster time indicates a better score. Box plots show median, interquartile range, minimum, and maximum. FTSS median test time (interquartile range) preprogram, 14.23 s (7.15 s); postprogram, 11.88 s (5.44 s); 6-month follow-up, 10.75 s (6.92 s). One participant used one upper extremity for support to rise to standing during testing. **P<0.001.

changes preprogram-postprogram. Twenty-three participants had initial Patient Health Questionnaire-9 depression screen scores at preprogram: 11.5% (n=2) in the moderately severe to severe depression category, 17.4% (n=4) in moderate depression category, 69.6% (n=16) in the minimum to mild depression category, and 4.3% (n=1) in the no depression category. These depression category proportions remained mostly unchanged at postprogram, where 24 participant scores were available, with 11.5% (n=2) in the moderately severe to severe depression category, 11.5% (n=2) in moderate depression category, 70.8% (n=17) in the minimum to mild depression category, and 12.5% (n=3) in the no depression category. Although a few participants noted no changes to mood or outlook as a result of the program, many participants noted improvements in emotional health, including reduced depression, contributions to a positive attitude, and improved self-perception. Participants noted a new or renewed sense of enthusiasm for exercise or for engaging in activities and feeling more confident about their abilities.

> *Participant 12: "Overall experience was, it was, it was kind of life changing. Kind of life saving. Um, definitely haven't been nearly as depressed as I was before I came in here. Not at all. Um, and that doesn't just have to do with [life change]. It was, it was night and day difference. After about 2 weeks of being in here, it was night and day difference. From being really dark and, and in a really bad way. Um, really depressed, and, and trying to almost, uh, not really sure what to do with it, and I kind of starting, getting faith again, hope, feeling good, wanting to take care of myself, and, and just being happy."*

Exercise Self-Efficacy, Exercise Outcome Expectations, and Postprogram Exercise

Participants had high initial scores for both the Short Self-Efficacy for Exercise Scale (median, 4.20 of 5) and the Short Outcome Expectations for Exercise Scale (median, 4 of 5), indicating their confidence to exercise was high and that they anticipated benefits from exercise. Changes postprogram were not statistically significant (P>0.01).

Postprogram Exercise Plans

All completers had plans to continue exercise postprogram. Plans included continuing at CR through the self-pay maintenance program, participating in group-based exercise classes, joining a gym for aerobic and strength activities, doing exercise at home, and working with a personal trainer.

At 6-month follow-up, 83.3% (15/18) of participants reported engaging in exercise at least once a week, 44.4% (8/18) with a frequency of 1 to 3 times a week, and 38.9% (7/18) with a frequency of >3 times a week. Reported activities included walking (50%), gym strengthening (22.2%), gym aerobic (50%), home

aerobic (33.3%), home strengthening (11.1%), group exercise (22.2%), and other (22.2%), which included swimming, yardwork, horseback riding, and running.

DISCUSSION

After participation in exercise-based CR, survivors of stroke made improvements in cardiovascular endurance, functional strength, and perceived mobility. Improvements in cardiovascular endurance and functional strength were maintained at the 6-month follow-up, suggesting the possibility of lasting changes. Qualitative results confirmed endurance and mobility improvements and highlighted additional improvements in emotional health. Improvements occurred regardless of self-reported prior activity levels. Previous exercise experience combined with high levels of exercise self-efficacy may have been a driver for initial participation.

Cardiovascular Endurance

Survivors Improve Cardiovascular Endurance

Survivors of stroke integrated into exercise-based CR demonstrated improvements in cardiovascular endurance. The 6MWT improvements suggest better community walking status and real-world walking capability.[42,56] This increase in capacity is especially important to survivors of stroke who have mobility impairments that result in a higher energy cost for walking.[56] The 6MWT improvements were maintained at 6-month follow-up, supporting maintenance of gains after exercise-based CR. The 61.92-mchange preprogram-postprogram was greater than a pooled mean change of 53.3 m from a recent meta-analysis of aerobic programs for stroke survivors with similar dosage to CR.[57] Maximum METs had a median increase of 3.6 METs preprogram-postprogram. These changes are important measures of overall health. A meta-analysis by Kodama et al found that in healthy individuals, for each one MET increase in exercise capacity, all-cause mortality was reduced by 13% and incidence of coronary heart disease and cardiovascular disease was reduced by 15%.[58] Similar results have been found for traditional CR participants.[59] The SIS-Mobility scale measures participant perception of home and community mobility capabilities, and improvement preprogram to postprogram corroborates the link between capacity and participation. These results were not maintained at 6-month follow-up, however. The addition of social support from other participants and from staff during the exercise-based CR program may have impacted the SIS-Mobility results, which did not continue in the follow-up period.[60] Qualitative themes of improved stamina impacting participant's daily activities support the quantitative findings of improved cardiovascular endurance and overall mobility.

Other Physical and General Health Outcomes

Survivors Improve Functional Strength

Lower extremity strength improved preprogram to postprogram and was maintained at 6-month follow-up. In addition to measuring strength, the 5 times sit to stand test has speed and control components and functional correlates.[54,61,62] For survivors of stroke, taking longer to complete the 5 times sit to stand test correlates with lower bilateral knee flexor strength and increased risk of falls.[54,62] For geriatric populations, which often include survivors of stroke, a slower time is predictive of less independence in activities of daily living within 3 years.[63] Collectively, improvements in cardiovascular endurance and strength support the positive health and fitness benefits of integration of survivors of stroke into US-based CR exercise programs.

Emotional Health and Self-Efficacy for Exercise Had Ceiling Effects and Mixed Results

The initial scores measuring this construct indicated low initial depression in the sample (73.9% with no to mild depression on the Patient Health Questionnaire-9) and higher initial mood (median of 77.78% on the SIS-Mood subscale), leaving little room for change. Qualitative results suggest that participation in exercise-based CR may impact emotional health for individuals, and this is supported by existing research.[64–67] The qualitative themes related to emotional health were participants finding renewed self-confidence and sense of self. Higher self-esteem is known to positively impact self-perception of identity after stroke.[65–67] A qualitative study by Erikson et al found that finding a positive new self-identity after stroke was tied to engaging with others through meaningful activities, which a program like CR can provide.[66]

Self-efficacy for exercise and outcome expectation for exercise scores were high at preprogram, suggesting good to excellent confidence in exercise abilities (Short Self-Efficacy for Exercise Scale: median, 4.2) and belief in benefits of exercise (Short Outcome Expectations for Exercise Scale: median, 4.0). With a maximum score of 5 on both the Short Self-Efficacy for Exercise Scale and the Short Outcome Expectations for Exercise Scale, achieving significant changes was difficult because of a ceiling effect. The high initial scores in this sample may be related to the importance of having self-efficacy and positive outcome expectations to commit to structured exercise programs.[68,69] All of the completers had concrete plans for continued

exercise at the completion of the program. At 6 months, most were still active, suggesting that 12 weeks may be long enough to build habits for maintained activity. However, improved exercise habit results require more investigation, as this sample had a high proportion of participants with high self-efficacy for exercise and some exercise experience before the program, both key drivers of ongoing PA in survivors of stroke.[69]

Study Limitations

There are several study limitations related to the use of a single-group pilot design with a convenience sample at a single exercise-based CR program. Deliberately broad inclusion criteria allowed for capturing survivors in both the subacute and chronic phases of recovery. Chronic stroke survivors face persistent significant deficits in endurance, strength, and gait speed and the cardiovascular disease risk factors accompanying these deficits.[70] The amount of benefit for those in the chronic phase is promising and suggests continued study for this population. Future studies with larger sample sizes may determine more clear pathways to the program and address potentially divergent needs between the 2 subgroups. Although a diverse sample of mobility impairments, sex, age, and racial/ethnic diversity was desired, most participants were White men with few mobility limitations and relatively high initial fitness levels. Future studies for survivors with less functional mobility may require further screening and expansion of CR protocols. In addition, future studies can expand to multiple health system sites and use a randomized control trial design with recruiting plans targeting participants with specific characteristics. Low participation rate for referred potential study participants mirrors participation rates for traditional CR participants, which can be as low as 20% to 30%.[71] Institutional barriers, healthcare provider barriers, and individual barriers require exploration before successful implementation of future phase trials and community implementation. Uptake rates may be addressed through institutional buy-in, education for healthcare providers and survivors of stroke, and elimination of barriers, where possible, before implementation. Study participants' failure to use the available education sessions was a missed opportunity for additional potential behavior change. Confusion by staff on study participant eligibility and participant belief that it was not necessary or appropriate to them were barriers that could be addressed with better education of staff in future studies.

CONCLUSIONS

Exercise-based CR for survivors of stroke had a positive impact on cardiovascular endurance and functional strength. Exercise-based CR also influenced participants' perception of their home and community mobility, their walking capability, and their emotional health. Improvements in METs correspond to reduced risk for mortality and cardiovascular disease. Despite similar cardiovascular risk factors to traditional CR participants and potential health benefits from participation, stroke is not among the covered diagnoses for CR services in the United States. Findings support the use of CR exercise programs for survivors of stroke after rehabilitation to improve endurance, health status, and quality of life. Further investigations can confirm findings and explore integrating survivors of stroke as a standard of care.

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Disclosures

None.

Supplementary Material

Data S1
Tables S1–S2

REFERENCES

1. Benjamin EJ, Muntner P, Bittencourt MS. Heart disease and stroke statistics-2019 update: a report from the American Heart Association. *Circulation*. 2019;139:e56–e528.
2. Hardie K, Hankey GJ, Jamrozik K, Broadhurst RJ, Anderson C. Ten-year risk of first recurrent stroke and disability after first-ever stroke in the Perth Community Stroke Study. *Stroke*. 2004;35:731–735. DOI: 10.1161/01.STR.0000116183.50167.D9.
3. Butler EN, Evenson KR. Prevalence of physical activity and sedentary behavior among stroke survivors in the United States. *Top Stroke Rehabil*. 2014;21:246–255. DOI: 10.1310/tsr2103-246.
4. Jette DU, Latham NK, Smout RJ, Gassaway J, Slavin MD, Horn SD. Physical therapy interventions for patients with stroke in inpatient rehabilitation facilities. *Phys Ther*. 2005;85:238–248. DOI: 10.1093/ptj/85.3.238.
5. Buntin MB, Colla CH, Deb P, Sood N, Escarce JJ. Medicare spending and outcomes after post-acute care for stroke and hip fracture. *Med Care*. 2010;48:776. DOI: 10.1097/MLR.0b013e3181e359df.
6. Blennerhassett JM, Levy CE, Mackintosh A, Yong A, McGinley JL. One-quarter of people leave inpatient stroke rehabilitation with physical capacity for community ambulation. *J Stroke Cerebrovasc Dis*. 2018;27:3404–3410.
7. MacKay-Lyons MJ, Makrides L. Longitudinal changes in exercise capacity after stroke. *Arch Phys Med Rehabil*. 2004;85:1608–1612.

8. Boyne P, Billinger S, MacKay-Lyons M, Barney B, Khoury J, Dunning K. Aerobic exercise prescription in stroke rehabilitation: a web-based survey of United States physical therapists. *J Neurol Phys Ther*. 2017;41:119.
9. Robinson CA, Shumway-Cook A, Ciol MA, Kartin D. Participation in community walking following stroke: subjective versus objective measures and the impact of personal factors. *Phys Ther*. 2011;91:1865–1876. DOI: 10.2522/ptj.20100216.
10. Michael KM, Allen JK, Macko RF. Reduced ambulatory activity after stroke: the role of balance, gait, and cardiovascular fitness. *Arch Phys Med Rehabil*. 2005;86:1552–1556. DOI: 10.1016/j.apmr.2004.12.026.
11. Kono Y, Kawajiri H, Kamisaka K, Kamiya K, Akao K, Asai C, Inuzuka K, Yamada S. Predictive impact of daily physical activity on new vascular events in patients with mild ischemic stroke. *Int J Stroke*. 2015;10:219–223. DOI: 10.1111/ijs.12392.
12. Hebert D, Lindsay MP, McIntyre A, Kirton A, Rumney PG, Bagg S, Bayley M, Dowlatshahi D, Dukelow S, Garnhum M, et al. Canadian stroke best practice recommendations: stroke rehabilitation practice guidelines, update 2015. *Int J Stroke*. 2016;11:459–484. DOI: 10.1177/1747493016643553.
13. Woodman P, Riazi A, Pereira C, Jones F. Social participation post stroke: a meta-ethnographic review of the experiences and views of community-dwelling stroke survivors. *Disabil Rehabil*. 2014;36:2031–2043. DOI: 10.3109/09638288.2014.887796.
14. Billinger SA, Arena R, Bernhardt J, Eng JJ, Franklin BA, Johnson CM, MacKay-Lyons M, Macko RF, Mead GE, Roth EJ, et al. Physical activity and exercise recommendations for stroke survivors a statement for healthcare professionals from the American Heart Association/American Stroke Association. *Stroke*. 2014;45:2532–2553. DOI: 10.1161/STR.0000000000000022.
15. Patterson S, Ross-Edwards B. Long-term stroke survivors' needs and perceptions of an exercise maintenance model of care. *Int J Ther Rehabil*. 2009;16:659–669. DOI: 10.12968/ijtr.2009.16.12.45422.
16. Curnier DY, Savage PD, Ades PA. Geographic distribution of cardiac rehabilitation programs in the United States. *J Cardiopulm Rehabil Prev*. 2005;25:80–84. DOI: 10.1097/00008483-200503000-00006.
17. Humen D, Higgins G, Unsworth K, Prior P, Massel D, Suskin N. A cost analysis of event reduction provided by a comprehensive cardiac rehabilitation program. *Can J Cardiol*. 2013;29:S156. DOI: 10.1016/j.cjca.2013.07.232.
18. Bellet RN, Adams L, Morris NR. The 6-minute walk test in outpatient cardiac rehabilitation: validity, reliability and responsiveness—a systematic review. *Physiotherapy*. 2012;98:277–286. DOI: 10.1016/j.physio.2011.11.003.
19. Anderson L, Taylor RS. Cardiac rehabilitation for people with heart disease: an overview of Cochrane systematic reviews. *Int J Cardiol*. 2014;177:348–361. DOI: 10.1016/j.ijcard.2014.10.011.
20. Marzolini S, Tang A, McIlroy W, Oh PI, Brooks D. Outcomes in people after stroke attending an adapted cardiac rehabilitation exercise program: does time from stroke make a difference? *J Stroke Cerebrovasc Dis*. 2014;23:1648–1656. DOI: 10.1016/j.jstrokecerebrovasdis.2014.01.008.
21. Boss H, Van Schaik S, Deijle I, de Melker E, van den Berg B, Scherder E, Bosboom WM, Weinstein HC, den Berg-Vos V. Safety and feasibility of post-stroke care and exercise after minor ischemic stroke or transient ischemic attack: MotiveS & MoveIT. *NeuroRehabilitation*. 2014;34:401–407.
22. Lennon O, Carey A, Gaffney N, Stephenson J, Blake C. A pilot randomized controlled trial to evaluate the benefit of the cardiac rehabilitation paradigm for the non-acute ischaemic stroke population. *Clin Rehabil*. 2008;22:125–133. DOI: 10.1177/0269215507081580.
23. Biasin L, Sage MD, Brunton K, Fraser J, Howe JA, Bayley M, Brooks D, McLlroy WE, Mansfield A, Inness EL. Integrating aerobic training within subacute stroke rehabilitation: a feasibility study. *Phys Ther*. 2014;94:1796–1806. DOI: 10.2522/ptj.20130404.
24. Cuccurullo SJ, Fleming TK, Kostis WJ, Greiss C, Gizzi MS, Eckert A, Ray AR, Scarpati R, Cosgrove NM, Beavers T, et al. Impact of a stroke recovery program integrating modified cardiac rehabilitation on all-cause mortality, cardiovascular performance and functional performance. *Am J Phys Med Rehabil*. 2019;98:953–963. DOI: 10.1097/PHM.0000000000001214.
25. Lennon O, Blake C. Cardiac rehabilitation adapted to transient ischaemic attack and stroke (CRAFTS): a randomised controlled trial. *BMC Neurol*. 2009;9:9. DOI: 10.1186/1471-2377-9-9.
26. Kirk H, Kersten P, Crawford P, Keens A, Ashburn A, Conway J. The cardiac model of rehabilitation for reducing cardiovascular risk factors post transient ischaemic attack and stroke: a randomized controlled trial. *Clin Rehabil*. 2014;28:339–349. DOI: 10.1177/0269215513502211.
27. Marzolini S. Integrating individuals with stroke into cardiac rehabilitation following traditional stroke rehabilitation: promoting a continuum of care. *Can J Cardiol*. 2018;34:S240–S246. DOI: 10.1016/j.cjca.2018.06.017.
28. Tang A, Marzolini S, Oh P, McIlroy WE, Brooks D. Feasibility and effects of adapted cardiac rehabilitation after stroke: a prospective trial. *BMC Neurol*. 2010;10:40. DOI: 10.1186/1471-2377-10-40.
29. US Centers for Medicare and Medicaid Services. Your Medicare coverage: cardiac rehabiltiation programs. Available at: http://www.medicare.gov/coverage/cardiac-rehab-programs.html. Accessed March 5, 2020.
30. Regan E. Integrating stroke survivors into cardiac rehabilitation. OSF. Available at: https://osf.io/cqm5p/?view_only=77549d0e26b944a0b34dfb9295a635e2. Accessed August 13, 2020.
31. Dunbar CC, Robertson RJ, Baun R, Blandin MF, Metz K, Burdett R, Goss FL. The validity of regulating exercise intensity by ratings of perceived exertion. *Med Sci Sports Exerc*. 1992;24:94–99. DOI: 10.1249/00005768-199201000-00016.
32. Santiago de Araújo Pio C, Beckie TM, Varnfield M, Sarrafzadegan N, Babu AS, Baidya S, Buckley J, Chen S-Y, Gagliardi A, Heine M, et al. Promoting patient utilization of outpatient cardiac rehabilitation: a joint international council and Canadian association of cardiovascular prevention and rehabilitation position statement. *Int J Cardiol*. 2020;298:1–7. DOI: 10.1016/j.ijcard.2019.06.064.
33. Shiran A, Kornfeld S, Zur S, Laor A, Karelitz Y, Militianu A, Merdler A, Lewis BS. Determinants of improvement in exercise capacity in patients undergoing cardiac rehabilitation. *Cardiology*. 1997;88:207–213. DOI: 10.1159/000177331.
34. Flansbjer U-B, Holmbäck AM, Downham D, Patten C, Lexell J. Reliability of gait performance tests in men and women with hemiparesis after stroke. *J Rehabil Med*. 2005;37:75–82. DOI: 10.1080/16501970410017215.
35. Lai S-M, Studenski S, Duncan PW, Perera S. Persisting consequences of stroke measured by the stroke impact scale. *Stroke*. 2002;33:1840–1844. DOI: 10.1161/01.STR.0000019289.15440.F2.
36. Nadarajah M, Mazlan M, Abdul-Latif L, Goh H. Test-retest reliability, internal consistency and concurrent validity of Fatigue Severity Scale in measuring post-stroke fatigue. *Eur J Phys Rehabil Med*. 2017;53:703–709.
37. Botner EM, Miller WC, Eng JJ. Measurement properties of the activities-specific balance confidence scale among individuals with stroke. *Disabil Rehabil*. 2005;27:156–163. DOI: 10.1080/09638280400008982.
38. Mong Y, Teo TW, Ng SS. 5-Repetition sit-to-stand test in subjects with chronic stroke: reliability and validity. *Arch Phys Med Rehabil*. 2010;91:407–413. DOI: 10.1016/j.apmr.2009.10.030.
39. Shaughnessy M, Resnick BM, Macko RF. Reliability and validity testing of the short self-efficacy and outcome expectation for exercise scales in stroke survivors. *J Stroke Cerebrovasc Dis*. 2004;13:214–219. DOI: 10.1016/j.jstrokecerebrovasdis.2004.07.002.
40. Williams LS, Brizendine EJ, Plue L, Bakas T, Tu W, Hendrie H, Kroenke K. Performance of the PHQ-9 as a screening tool for depression after stroke. *Stroke*. 2005;36:635–638. DOI: 10.1161/01.STR.0000155688.18207.33.
41. Beninato M, Portney LG, Sullivan PE. Using the International Classification of Functioning, Disability and Health as a framework to examine the association between falls and clinical assessment tools in people with stroke. *Phys Ther*. 2009;89:816–825. DOI: 10.2522/ptj.20080160.
42. Fulk GD, He Y, Boyne P, Dunning K. Predicting home and community walking activity poststroke. *Stroke*. 2017;48:406–411. DOI: 10.1161/STROKEAHA.116.015309.
43. Lajoie Y, Gallagher S. Predicting falls within the elderly community: comparison of postural sway, reaction time, the Berg balance scale and the Activities-specific Balance Confidence (ABC) scale for comparing fallers and non-fallers. *Arch Gerontol Geriatr*. 2004;38:11–26. DOI: 10.1016/S0167-4943(03)00082-7.
44. Langhammer B, Stanghelle JK, Lindmark B. An evaluation of two different exercise regimes during the first year following stroke: a

randomised controlled trial. *Physiother Theory Pract*. 2009;25:55–68. DOI: 10.1080/09593980802686938.
45. Feise RJ. Do multiple outcome measures require p-value adjustment? *BMC Med Res Methodol*. 2002;2:8. DOI: 10.1186/1471-2288-2-8.
46. Patton MQ. *Qualitative Research and Evaluation Methods*. Thousand Oaks, CA: Sage Publications; 2015.
47. Morgan DL. Pragmatism as a paradigm for social research. *Qual Inq*. 2014;20:1045–1053. DOI: 10.1177/1077800413513733.
48. Bandura A. Social cognitive theory of self-regulation. *Organ Behav Hum Decis Process*. 1991;50:248–287. DOI: 10.1016/0749-5978(91)90022-L.
49. World Health Organization. International classification of functioning, disability and health (ICF). 2017. Available at: http://www.who.int/classifications/icf/en/. Accessed March 5, 2020.
50. Morse JM. *Determining Sample Size*. Thousand Oaks, CA: Sage Publications; 2000.
51. Tong A, Sainsbury P, Craig J. Consolidated criteria for reporting qualitative research (COREQ): a 32-item checklist for interviews and focus groups. *Int J Qual Health Care*. 2007;19:349–357. DOI: 10.1093/intqhc/mzm042.
52. Braun V, Clarke V. Using thematic analysis in psychology. *Qual Res Psychol*. 2006;3:77–101. DOI: 10.1191/1478088706qp063oa.
53. Lin K, Fu T, Wu C, Wang Y, Liu J, Hsieh C, Lin SF. Minimal detectable change and clinically important difference of the stroke impact scale in stroke patients. *Neurorehabil Neural Repair*. 2010;24:486–492. DOI: 10.1177/1545968309356295.
54. Kwong PW, Ng SS, Chung RC, Ng GY. Foot placement and arm position affect the five times sit-to-stand test time of individuals with chronic stroke. *Biomed Res Int*. 2014;2014:636530. DOI: 10.1155/2014/636530.
55. Eng JJ, Dawson AS, Chu KS. Submaximal exercise in persons with stroke: test-retest reliability and concurrent validity with maximal oxygen consumption. *Arch Phys Med Rehabil*. 2004;85:113–118.
56. Ribeiro JA, Oliveira SG, Thommazo-Luporini LD, Monteiro CI, Phillips SA, Catai AM, Borghi-Silva A, Russo TL. Energy cost during the 6-minute walk test and its relationship to real-world walking after stroke: a correlational, cross-sectional pilot study. *Phys Ther*. 2019;99:1656–1666.
57. Regan EW, Handlery R, Beets MW, Fritz SL. Are aerobic programs similar in design to cardiac rehabilitation beneficial for survivors of stroke? A systematic review and meta-analysis. *J Am Heart Assoc*. 2019;8:e012761. DOI: 10.1161/JAHA.119.012761.
58. Kodama S, Saito K, Tanaka S, Maki M, Yachi Y, Asumi M, Sugawara A, Totsuka K, Shimano H, Ohashi Y. Cardiorespiratory fitness as a quantitative predictor of all-cause mortality and cardiovascular events in healthy men and women: a meta-analysis. *JAMA*. 2009;301:2024–2035. DOI: 10.1001/jama.2009.681.
59. Martin B-J, Arena R, Haykowsky M, Hauer T, Austford LD, Knudtson M, Aggarwal S, Stone JA; APPROACH Investigators. Cardiovascular fitness and mortality after contemporary cardiac rehabilitation. *Mayo Clin Proc*. 2013;88:455–463. DOI: 10.1016/j.mayocp.2013.02.013.
60. Cott CA, Wiles R, Devitt R. Continuity, transition and participation: preparing clients for life in the community post-stroke. *Disabil Rehabil*. 2007;29:1566–1574. DOI: 10.1080/09638280701618588.
61. Lord SR, Murray SM, Chapman K, Munro B, Tiedemann A. Sit-to-stand performance depends on sensation, speed, balance, and psychological status in addition to strength in older people. *J Gerontol A Biol Sci Med Sci*. 2002;57:M539–M543. DOI: 10.1093/gerona/57.8.M539.
62. Buatois S, Perret-Guillaume C, Gueguen R, Miget P, Vançon G, Perrin P, Benetos A. A simple clinical scale to stratify risk of recurrent falls in community-dwelling adults aged 65 years and older. *Phys Ther*. 2010;90:550–560. DOI: 10.2522/ptj.20090158.
63. Zhang F, Ferrucci L, Culham E, Metter EJ, Guralnik J, Deshpande N. Performance on five times sit-to-stand task as a predictor of subsequent falls and disability in older persons. *J Aging Health*. 2013;25:478–492. DOI: 10.1177/0898264313475813.
64. Eng JJ, Reime B. Exercise for depressive symptoms in stroke patients: a systematic review and meta-analysis. *Clin Rehabil*. 2014;28:731–739. DOI: 10.1177/0269215514523631.
65. Lapadatu I, Morris R. The relationship between stroke survivors' perceived identity and mood, self-esteem and quality of life. *Neuropsychol Rehabil*. 2019;29:199–213. DOI: 10.1080/09602011.2016.1272468.
66. Erikson A, Karlsson G, Tham K. Living with the long-term consequences 11–13 years after stroke: a phenomenological study. *J Rehabil Med*. 2016;48:847–852. DOI: 10.2340/16501977-2161.
67. Morris JH, Oliver T, Kroll T, Joice S, Williams B. Physical activity participation in community dwelling stroke survivors: synergy and dissonance between motivation and capability: a qualitative study. *Physiotherapy*. 2017;103:311–321. DOI: 10.1016/j.physio.2016.05.001.
68. Dixon G, Thornton EW, Young CA. Perceptions of self-efficacy and rehabilitation among neurologically disabled adults. *Clin Rehabil*. 2007;21:230–240. DOI: 10.1177/0269215506071784.
69. Morris JH, MacGillivray S, McFarlane S. Interventions to promote long-term participation in physical activity after stroke: a systematic review of the literature. *Arch Phys Med Rehabil*. 2014;95:956–967. DOI: 10.1016/j.apmr.2013.12.016.
70. Severinsen K, Jakobsen JK, Overgaard K, Andersen H. Normalized muscle strength, aerobic capacity, and walking performance in chronic stroke: a population-based study on the potential for endurance and resistance training. *Arch Phys Med Rehabil*. 2011;92:1663–1668. DOI: 10.1016/j.apmr.2011.04.022.
71. Ades PA, Keteyian SJ, Wright JS, Hamm LF, Lui K, Newlin K, Shepard DS, Thomas RJ. Increasing cardiac rehabilitation participation from 20% to 70%: a road map from the Million Hearts Cardiac Rehabilitation Collaborative. *Mayo Clin Proc*. 2017;92:234–242. DOI: 10.1016/j.mayocp.2016.10.014.

SUPPLEMENTAL MATERIAL

Data S1.

Health System Policy Summary

I. Safety - Events

a. Suspected cardiac arrest or patient fall
    i. CPR and medical procedures
b. Chest Pain / Angina
c. Arrythmias
    i. Monitor symptoms, perform ECG as warranted and then ACLS algorithm
d. Hypoglycemia
    i. Monitor symptoms, check as needed
    ii. If <90 mg/dL, glucose orally
e. Hyperglycemia
    i. Monitor symptoms, check as needed
    ii. If >25 mg/dL, no exercise without referring physician and site supervisor approval
f. Hypotension
    i. Check BP pre-, post- and as needed
    ii. If systolic < 90 mmHg or diastolic <60 mmHg, provide fluids, check pulse and rhythm
    iii. No exercise if does not recover
g. Hypertension
    i. Check BP pre-, post- and as needed
    ii. If systolic >170 mmHg or diastolic > 100 mmHg, rest and recheck after 5 minutes
    i. No exercise if does not recover

II. Safety – Equipment

a. Provide instructions and use precautions individually for each piece of equipment

III. Exercise Protocol

a. Frequency: 3 x week for 12 weeks plus 2-4 days of prescribed home aerobic exercise during the 12 week period
b. Duration: started and progressed individually
    i. Guidelines: (1) Warm Up 8-10 minutes RPE 9-11 (light), (2) Training Period 10-40 minutes RPE 11-14 (moderate), (3) Cooldown 5-10 minutes RPE 9-11 (light)
c. Intensity:
    i. Initial determined by 6MWT results formula, or alternatively exercise stress test. If neither available, use 20-30 bpm above resting heart rate. Anticipated efforts to be 60-85% Heart Rate Reserve, oxygen saturation > 90%, and Dyspnea < 3.
    ii. Intensity can be progressed weekly
    iii. Intensity can be modified based on mobility issues, patient's response to exercise within exercise physiologist or nurse judgement

Table S1. Outcome Measures.

Outcome Measure	Assessment	Procedures
Six-Minute Walk Test	• Cardiovascular Endurance; walking capacity; initial fitness in CR programs[18, 34] • Measured as distance in meters	Participants were instructed to walk as far as possible in six minutes around an indoor track. They could stop and rest as needed, but timing continued. Once six minutes passed, the distance walked was recorded.
Five-Times Sit to Stand Test	• Functional Lower Body Strength[38, 54] • Measured as seconds to complete	Participants started sitting in a chair with arms across the chest and were asked to stand up and sit back down five times as quickly as possible without using their upper extremities to assist. If participants required procedure alterations, it was noted. One trial was completed.
Ten-meter Walk Test	• Self-Selected and Fast Walking Speed[34, 55] • Measured as meters/second	The testing area included a 5-meter acceleration area, a 10-meter timed area, and a 5-meter deceleration area. Use of assistive devices was noted. Three trials were completed for each condition.
Maximum Metabolic Equivalents (METs) *	• Standard measure of exercise tolerance and functional capacity in CR programs.[31] • Measured from 1 (very low) to 13 (very high) fitness.	Maximum METs were initially estimated based on the initial 6MWT and are progressed weekly based on improving fitness to match a rating of perceived exertion of 14 (somewhat hard).
Activities-Specific Balance Confidence Scale	• Self-Perception of Balance Confidence[37] • Total score 0-100% Confidence • A score less than 67% indicates an increased risk of falls.[65]	Questionnaire rating the self-perception of the individual's confidence to perform 16 activities without becoming unsteady or losing balance (0% "no confidence" to 100% "completely confident").
Stroke Impact Scale	• Impact of stroke on eight domains: mobility, participation, activities of daily living, hand function, strength, communication, emotion and memory/thinking.[35] • Domain sub scores from 0% (significant impact) to 100% (no impact).	Self-Report questionnaire where each domain is rated by a series of questions from 1-high impact to 5-minimal/ no impact.
Short Self-Efficacy and Outcome Expectations for Exercise (SSEE and SOEE)	• Confidence to complete exercise behaviors such as exercising alone or through fatigue.[39] • Exercise outcome expectations such as belief that exercise improves mood or improves endurance. [39] • Scores are 1 (low) to 5 (high)	Self-Report questionnaires. The SSEE (5 items) on a scale of 1 (not confident) to 5 (very confident). The SOEE (5-items) on a scale of 1(strongly disagree) to 5(strongly agree).
Patient Health Questionnaire-9	• Depression[40] • Total score of 0-27 with categories of 0 (no depression), 1 to 9 (minimum to mild), 10 to 14 (moderate), and 15 to 27 (moderately severe to severe).	Nine-item self-report on a scale of 0 (not at all) to 3 (nearly every day)

* Maximum Metabolic Equivalents were calculated at the initial visit and final visits as part of the standard program and were not re-assessed at six-month follow-up.

Table S2. Qualitative Interview Guide.

Question	Topic
Tell me a little bit about your stroke experience? If they had rehabilitation: What was your rehab experience? What was it like when you finished rehabilitation?	Background / exercise experience / Context
How did you find out about the program? Where? From Who?	Process – Recruitment
What information was provided about the program?	Process – Recruitment
What were the reason(s) you wanted to participate when you first heard about the program? What motivated to you come? What motivated you to continue to come?	Facilitators / Exercise& Health Beliefs
Tell me about your experience getting started (Schedule, initial visit, beginning program)	Process – Research Process
What did you expect the program would be like? In what ways did it meet your expectations or not meet your expectations?	Process-Recruitment, Facilitators, Program Experience, Acceptability
What was your experience like in the program? What parts did you enjoy? What parts did you not enjoy?	Program Experience -Program Delivery, Acceptability
Tell me about an experience, if any, where you felt it was too easy or too hard? Tell me about an experience, if any, where you felt unsafe.	Program Experience-Program Delivery, Acceptability
Tell me about working with the Exercise Physiologist. What was that like? In what ways was it similar to working with a therapist (PT, OT, SLP)? In what ways was it different than working with a therapist (PT, OT, SLP)? Was there anything he did in supervising you that you wish was done differently? Anything that stands out in your mind as helpful?	Program Experience-Program Relationships
What did you think of the gym atmosphere? What was it like exercising with the other participants (Stroke/cardiac)? what did you talk about? (i.e. Did you feel accepted and a part of the gym?)	Program Experience-Program Delivery, Program Experience-Program Relationships
Tell me about any instances that interrupted your participation during the 3 months?	Barriers/Facilitators
What factors helped to participate regularly? (transportation, family support, relationships, results)	Barriers/Facilitators
What things would you change about the program?	Program Experience-Modifications, Acceptability
What, if any, impacts did the program have on your health?	Program Outcomes and Impact-physical
How do you think the program has impacted your mobility, if at all?	Program Outcomes and Impact-physical

Question	Topic
How do you think the program has impacted your mood and outlook? Your fatigue levels? Are there any activities that have become easier or harder since beginning the program?	Program Outcomes and Impact-QoL
How has the program impacted your level of independence in activities at home, at work, in the community?	Program outcomes and Impact-other, Activity and Community Participation
How has the program impacted your confidence in your abilities to move and participate in activities important to you?	Program outcomes and Impact-other, Exercise and Health Beliefs
Tell me about your beliefs about exercise's impact on your health. In what ways did participating in this program impact your health beliefs?	Exercise and Health Beliefs
Are there other ways the program has impacted you that we have not discussed? Did it change your perception of yourself in any ways we have not discussed?	Program outcomes and Impact-other
What were your goals for the program (if not already mentioned in why decided to join)?	Exercise and Health Beliefs
Tell me about your exercise habits before you had your stroke? What about after rehabilitation?	Background / Exercise experience / Context
What are your plans to continue to exercise now that the program is over? How will you accomplish these goals?	Activity and Community Participation
Do you have any feedback about the research process that we have not already discussed?	Process-Research Process
Any further comments or details you would like to share?	