Outcomes in People after Stroke Attending an Adapted Cardiac Rehabilitation Exercise Program: Does Time from Stroke Make a Difference?

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Background: Individuals referred to cardiac rehabilitation programs (CRPs) after stroke have demonstrated postprogram improvements in cardiovascular fitness (VO_{2peak}). However, the effect of CRPs on other physiological/quality-of-life outcomes and effect of time from stroke on these results has not been investigated. The objectives of the present study are (1) to evaluate the effects of a CRP in participants with motor impairment after stroke and (2) to explore the effects of elapsed time from stroke on physiological/quality-of-life outcomes. *Methods:* The CRP included 24 weeks of resistance and aerobic training. Primary outcomes in 120 participants, 25.4 ± 42.3 (mean ± standard deviation) months after stroke, included 6-minute walk distance (6MWD), VO_{2peak}, timed repeated sit-to-stand performance, and affected-side isometric knee extensor strength (IKES). Secondary measures included gait characteristics (cadence, step lengths, and symmetry), walking speed, balance (Berg Balance Scale), affected-side range of motion (ROM), elbow flexor and grip strength, anaerobic threshold, and perceptions of participation/social reintegration. *Results:* After adjusting for multiple comparisons, participants demonstrated significant improvements (all $P < .001$) in 6MWD (283.2 ± 126.6 to 320.7 ± 141.8 m), sit-to-stand performance (16.3 ± 9.5 to 13.3 ± 7.1 seconds), affected-side IKES (25.9 ± 10.1 to 30.2 ± 11 kg as a percentage of body mass), and VO_{2peak} (15.2 ± 4.5 to 17.2 ± 4.9 $mL \cdot kg \cdot min^{-1}$). Participants also demonstrated post-CRP improvements in secondary outcomes: anaerobic threshold, balance, affected-side hip/shoulder ROM, grip and isometric elbow flexor strength, participation, walking speed, cadence (all $P < .001$), and bilateral step lengths ($P < .04$). In a linear regression model, there was a negative association between the change in 6MWD and time from stroke ($\beta = -42.1$; $P = .002$) independent of baseline factors. *Conclusions:* A CRP yields improvements over multiple domains of recovery; however, those who start earlier demonstrate greater improvement in functional ambulation independent of baseline factors. These data support the use of adapted CRPs as a standard of care practice after conventional stroke rehabilitation. **Key Words:** Rehabilitation—stroke care—stroke delivery—stroke recovery.

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Introduction

Numerous studies have demonstrated that regular physical activity confers advantage to cardiovascular fitness and functional recovery for people after stroke.[1-3] Moreover, in a recent study, regular exercise and abstinence from smoking were each independently associated with lower all-cause mortality.[4] In recognition of the importance of exercise programming as a clinical stream in care after stroke, health associations across North America have issued recommendations to support physical activity as a therapeutic intervention after stroke.[5,6] Despite this, few stroke survivors exercise regularly.[4,7,8] This may be because structured exercise programs that are aimed at reducing risk of recurrent stroke are not widely available or accessible.[9,10] Cardiac rehabilitation programs (CRPs) may offer an important opportunity to fill this gap in service, as the exercise training components as well as risk factor interventions and assessments offered by these interprofessional health care teams are suited to facilitate long-term health behavior change for individuals after stroke. These include aerobic and resistance (strength) training, as well as nutrition and psychosocial counseling.

Although research evaluating the efficacy of adapted CRPs after stroke has focused on 1 key exercise-related outcome, cardiovascular fitness,[11,12] other dimensions of stroke recovery need to be considered. This is of importance as many individuals are left with neurologic impairments despite improved acute medical management.[13] These impairments can affect complex coordinated functioning such as mobility, ambulation, and sit-to-stand performance, as well as underlying muscular weakness.[14-16] As these sequelae can contribute to functional limitations, the impact of a CRP on these outcomes needs to be considered. Furthermore, although some studies reveal a recovery plateau focused primarily in the early phase of stroke recovery,[13,17-19] there is evidence that there is capacity to improve even in the chronic stages of stroke. Such improvements are evident from focused task retraining, and resistance training (RT) or aerobic training (AT) programs.[1,2,11,20-22] The challenge is that there is a paucity of programs and a need to identify potential program models that provide multidimensional benefits to stroke recovery.

Another issue that merits examination is the effectiveness of adapted CR treatments in relation to time elapsed after stroke. As noted, the typical stroke recovery profile features the greatest change over the first month, slower progression until the third month, and then an apparent plateau between 3 and 6 months.[13,17-19] Typical participants of adapted CRPs are referred at least 3 months to more than 5 years after the stroke event.[11,12,23] Given the wide range of referral times and that the greatest degree of recovery occurs early, it seems important to determine whether there is a potential benefit to beginning the CRP earlier and if those starting later still gain benefit.

The primary focus of the present prospective study was to determine if the CRP would augment not only the expected benefits in cardiorespiratory fitness but also improvements in sensorimotor control of the lower limbs (functional ambulation, sit-to-stand performance, and muscular strength). Secondarily, we set out to explore if the benefits derived were dependent on the duration between stroke onset and initiation of a CRP. We hypothesized that a CRP would result in improvements in multiple outcomes with no significant effect of time from stroke.

Materials and Methods

Patients were referred to Toronto Rehabilitation Institute's Risk Factor Modification and Exercise Program Following Stroke (TRI-REPS) from outpatient stroke rehabilitation programs, primary care physicians, and from the community. The TRI-REPS program is a substream of the Institute's CRP. To participate in the program patients had to be 12 weeks or more after stroke with a stroke-related motor impairment score of less than 7 on the Chedoke–McMaster Stroke Assessment (CMSA) scale of arm, hand, leg, or foot. A score of 1 indicates flaccid paralysis, 3 describes marked spasticity and weakness, 6 indicates near normal coordination of patterns of movement and no spasticity, and 7 describes normal movement.[24] All participants had to be able to ambulate 10 m or more independently with/without an assistive device with no significant limitations because of pain. The study was approved by the institution's Research Ethics Board and all participants provided written informed consent.

Testing Procedures

Primary Outcomes

Functional ambulation was measured by the 6-minute walk distance (6MWD) test, which measures the distance (in meters) that an individual can quickly walk in a period of 6 minutes on a 30-m course according to standardized instructions.[25] All subjects used the gait aids prescribed to them. At baseline, participants completed 2 6MWD tests on the same day, with 15 minutes rest between trials.

As described elsewhere,[23] a symptom-limited exercise test was performed on a semirecumbent cycle ergometer with specialized pedals to secure feet (Ergoline Select 1000, Germany), upright cycle (Ergoselect 200P, Germany), or a treadmill depending on balance, and ability to control the leg/foot position in pedals. Individuals who had excessive hemiparetic hip weakness had their leg stabilized by an elastic band looped around the thighs. Workload on the cycle ergometer was increased by either 8.3 or 16.7 W every minute. Breath-by-breath gas samples were collected via calibrated metabolic cart (SensorMedics Vmax Encore, CA) to determine peak oxygen uptake