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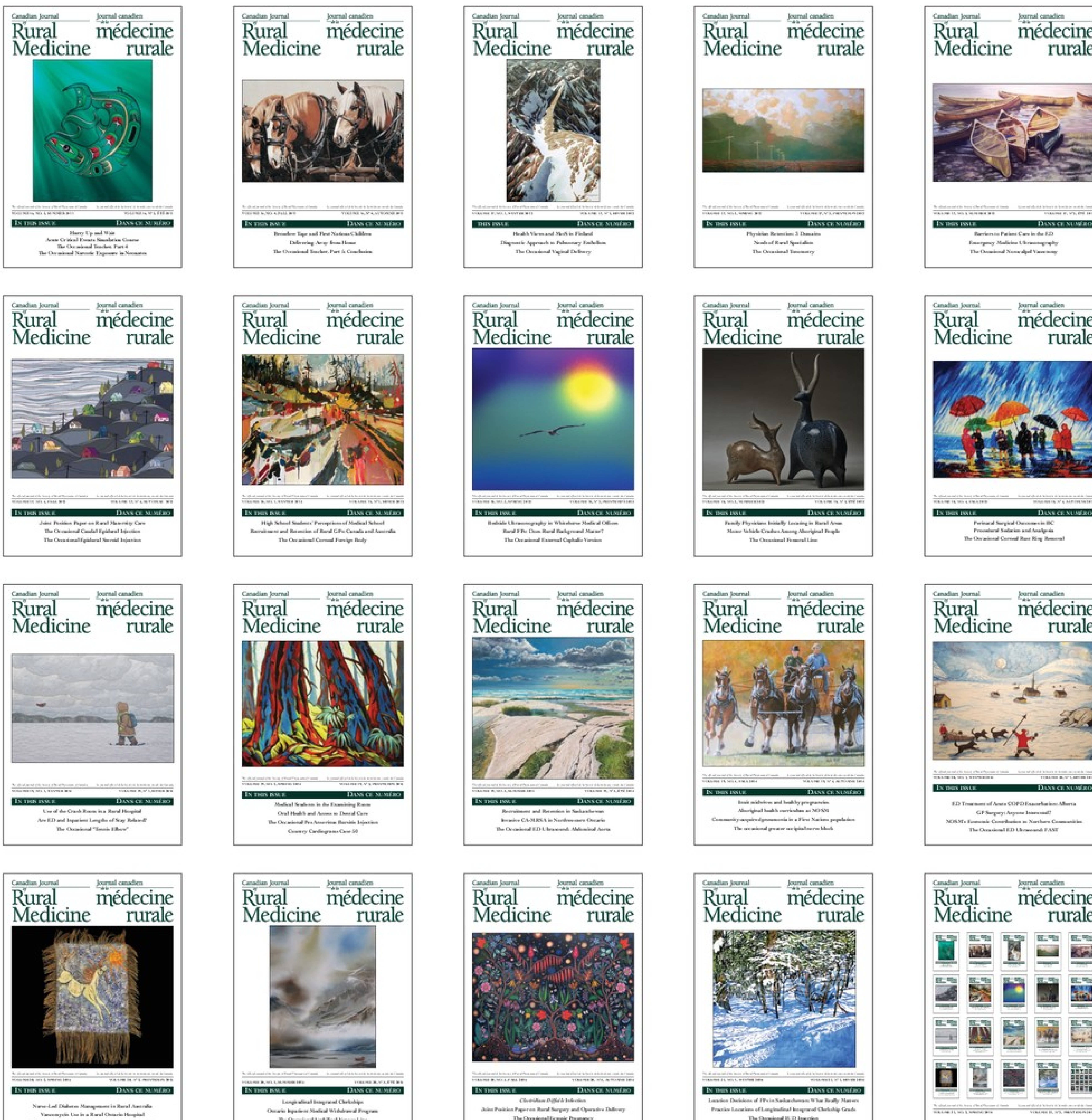

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Rural cardiac rehabilitation: a 20-year success story

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Introduction: Data are lacking on long-term participation in a clinically supervised cardiac rehabilitation program in a rural setting. We sought to determine whether there were sustained improvements in physiologic measures and discover what restorative and deteriorative processes took place over time.
Methods: We retrospectively analyzed the records of patients who were enrolled for a least 1 year in the Healthy Hearts Cardiac Rehabilitation Program. Data from stress tests were tracked for up to 18 years to determine whether there were any sustained improvements and what factors were associated with restorative and deteriorative processes.
Results: We analyzed data from 85 participants. The mean age of the participants was 72 years, and the mean length of participation was 8 years. Duration of stress testing significantly ($p < 0.01$) increased by a mean of 15% from the first year to the second year, with a corresponding increase in estimated metabolic equivalent of task (MET) level (Cohen $\partial = 0.82$). The increase in duration was sustained into the ninth year, with an overall increase of 35% compared with the first year of testing. After the ninth year, the duration and estimated MET levels declined.
Conclusion: Participants in the cardiac rehabilitation program demonstrated improved duration of stress testing, and stable rate-pressure product, blood pressure and resting heart rate during long-term participation in the program.

Introduction : On manque d'information sur la participation à long terme aux programmes de réadaptation cardiaque avec supervision clinique en milieu rural. Nous avons donc cherché à déterminer si ces programmes entraînent une amélioration physiologique permanente et à décrire les processus de guérison et d'aggravation qui surviennent au fil du temps.
Méthodes : Nous avons procédé à une analyse rétrospective des dossiers de patients qui ont participé au programme Healthy Hearts pendant au moins 1 an. Des données sur leurs résultats aux épreuves d'effort sur une période maximale de 18 ans ont été recueillies pour déterminer la présence d'améliorations durables et mettre en évidence les facteurs associés à la guérison et à l'aggravation.
Résultats : Nous avons étudié les dossiers de 85 patients; la durée de participation moyenne était de 8 ans, et l'âge moyen des participants, de 72 ans. La durée de l'épreuve d'effort a connu une augmentation significative de 15 % en moyenne ($p < 0,01$) de la première à la deuxième année, associée à une hausse correspondante de l'équivalent métabolique (MET) estimé (∂ de Cohen = 0,82). Cette augmentation s'est poursuivie jusqu'à la neuvième année, où la durée était supérieure de 35 % à celle de la première année. Par la suite, la durée de l'épreuve et le MET estimé ont commencé à diminuer.
Conclusion : Au cours de leur participation prolongée au programme, les patients ont réussi à augmenter la durée de leur épreuve d'effort, et le produit de leur tension systolique par la fréquence des contractions cardiaques, leur pression artérielle et leur fréquence cardiaque au repos sont demeurés stables.

INTRODUCTION

Over the past 5 decades, participation in cardiac rehabilitation programs has been shown to reduce mortality by up to 35%, improve lipid profiles, reduce hospital readmission rates and improve patients' quality of life.[1–5] Cardiac rehabilitation programs provide education and counselling services to help patients with heart conditions increase physical fitness, reduce symptoms, improve health and reduce the future risk of heart problems.

Research suggests that participation in higher levels of physical activity in leisure time has an inverse relation to mortality in patients after myocardial infarction.[6] In spite of these positive findings, participation rates in cardiac rehabilitation programs are low, with only 25%–31% of eligible men and 11%–20% of eligible women participating.[7,8]

Delivery of a medically supervised program in a rural setting is particularly challenging. Difficulties include lack of qualified medical personnel, adequate workout facilities and funding.[3,9–11] In a rural setting, travel distance and regular attendance of qualified personnel can be barriers to participation.[12] Potential participants face a variety of obstacles that reduce their likelihood of entering a program. Disability, age, travel distance, initial disease severity, diagnosis, sex and level of education are well-documented barriers.[13–15]

Even when an individual decides to join a cardiac rehabilitation program, there is documented difficulty in program adherence.[2,16–18] In a randomized clinical trial, researchers found that adherence to recommended levels of physical activity progressively worsened once participants had completed the second phase of a cardiac rehabilitation program.[19]

Although robust improvements in aerobic capacity in the 6 months following intervention with a cardiac rehabilitation program are well documented, there is limited evidence that these improvements are maintained for longer periods.[4] There is a lack of research involving participants in a cardiac rehabilitation program who maintained regular attendance and exercise over a prolonged period. In a 12-year follow-up study, Gerber and colleagues[6] found that patients who engaged in a 12-week cardiac rehabilitation program and then participated in nonstructured or leisure physical activity had a death rate about half of that of sedentary patients after myocardial infarction. However, data are lacking on the long-term effect of structured exercise in a cardiac rehabilitation program with documented stress tests, presenting conditions and laboratory data over the course of a program.

We present the findings of a retrospective study involving participants in a rural cardiac rehabilitation program over a period of 18 years. We sought to determine whether there were sustained improvements in physiologic measures and to discover what restorative and deteriorative processes took place over time.

METHODS

Participants

We retrospectively analyzed the records of participants whose names had been redacted from secondary data acquired from intake interviews, stress test results and laboratory findings from 1994 to 2004. Patient data were obtained for men and women who had attended the Healthy Hearts Cardiac Rehabilitation Program in a small rural community in Ontario and who were given the option of continuing the program indefinitely. The class has been held in the same recreation facility for 15 of the 20 years of the program. Participants were encouraged to attend for as long as they wished.

Program data

On entry into the program, a baseline stress test was obtained. Thereafter, stress tests were administered twice yearly, on average, by the same physician over most of the study period, until the participant's cardiac status was considered stable. The program operated in accordance with general guidelines produced by the American Association of Cardiovascular and Pulmonary Rehabilitation.[20]

Participants with a minimum of 1 year of program participation were entered into the study data set. Each file was coded per stress test, and the results were averaged to represent each year of program participation.

Each participant file was initially separated into 5 general categories that included coded general participant information (9 items), presenting condition information (17 items), stress test variables (19 items), laboratory results (12 items) and medication (13 categories, 109 items).

The first pilot study used the data from 20 participants. This was analyzed to determine if there were key categories or items that could assist in understanding processes that were improving (restorative) or stabilizing or deteriorating (deteriorative).

General program information

Because the medical director and program staff remained relatively constant, the exercise method was consistently applied over the study period. Currently, the Healthy Hearts program has about 150 participants and 18 exercise classes per week. Each participant attended a clinically supervised 1-hour exercise class twice per week. Physician-supervised classes are offered, which ensures close monitoring and quick access to medical intervention for higher-risk participants. Once the participants have achieved cardiac stability and reach an estimated metabolic equivalent of task (MET) level that enabled them to exercise independently, they were transferred to the group that was clinically supervised by a nonphysician. Estimated MET levels used in this study were based on level and duration achieved during the stress test and did not use exhaled gas analysis.

Stress test variable analyses

There were certain stress test results that were performed only as equipment became available. Complete data sets were available for the following variables: weight; pretest and peak heart rate, systolic and diastolic blood pressure values, and rate-pressure product; maximum estimated MET levels; stage; and time. Partial data sets were available for ST/HR (ST segment depression/heart rate) Index, and pretest and maximum oxygen saturation.

Statistical analyses

We completed consolidation of the results into the 5 categories and statistical analysis using *t* testing with Wilcoxon heteroscedasticity correction and matrix modelling. This was done to determine which categories and items would be most useful in identifying factors associated with participant health. We used SPSS, version 20, statistical analysis software. As a result of the pilot study, the laboratory and medication categories were eliminated owing to the variability of test frequency, complexity of dosage and inability to confirm adherence to medication.

The next phase of research involved input of participants' data, excluding the first 20 participants. Each of these participants' data were entered into identical categories: coded general participant information, presenting condition information and stress test variables. The 3 categories were then consolidated for all participants and statistically analyzed using SPSS to identify any areas of significance and health outcome measures observed. Because participants entered the program at different times, some nonnormally distributed variables were compared using the Wilcoxon signed-rank test. The use of analysis of variance and repeated-measures was not possible due to the heteroscedastic nature of the data. We used a p value of 0.01 instead of 0.05 to make the individual tests more conservative. We limited data analysis to 12 years because of the small number of participant stress tests and laboratory tests beyond this point.

The program's board of directors gave permission to use the data.

RESULTS

Participants

The data from 85 participants were analyzed. Sample sizes across time differed in this study owing to a variety of entry points into the program. Patients in this study had attended the program for a mean of 8 years, with participation ranging from 1 to 18 years. At entry into the program, the mean age of participants was 72.3 (range 44–83) years. Seventy-three of the participants were married; 28 were women and 57 were men. Of the participants, 25% had recurring medical conditions over the course of the program.

On average, participants entered the program with 5 presenting conditions. The top 5 were family history of heart disease (76%), hypercholesterolemia (68%), hypertension (58%), myocardial infarction (45%) and angina (42%) (Table 1).

Table 1. Presenting conditions of 85 participants in the cardiac rehabilitation program

Variable	No. (%) of participants
Family history of heart disease	65 (76)
Hypercholesterolemia	58 (68)
Hypertension	49 (58)
Myocardial infarction	38 (45)
Angina	36 (42)
Orthopedic injury	35 (41)
Inactive lifestyle	33 (39)
Obesity	28 (33)
Angioplasty	26 (31)
Bypass surgery	22 (26)
Diabetes	17 (20)
Atrial fibrillation	12 (14)
Congestive heart failure	8 (9)
Peripheral vascular disease	6 (7)
Cerebrovascular accident	5 (6)
Smoker	4 (5)
Cardiac valve disease	2 (2)

Duration of stress test

Stress test durations are shown in Figure 1. There was significant improvement ($p < 0.01$) in duration compared with the first year of rehabilitation after the cardiac incident up to and including the ninth year of participation, after which there was a decline.

Duration of stress testing increased by a mean of 15% from the first year to the second year of testing, with a corresponding increase in estimated MET level during stress testing (Cohen $\partial = 0.82$, $p < 0.01$). The increase in duration was sustained into the ninth year (Table 2), with an overall increase in duration of 35% compared with the first year of testing, after which duration and estimated MET levels declined (Fig. 2).

The mean sustained time during the first stress test was 357 seconds, and participants increased this level to a maximum of 519 seconds in the ninth year of participation in the program. Increased duration was also demonstrated in participants with more than 10 years of participation in the program (Fig. 2). The only difference between this long-term group ($n = 26$) and the entire group ($n = 85$) was that a maximum 25.5% increase in duration by the seventh year was observed in the long-term group versus a 35% increase by the ninth year in the overall group.

The typical estimated MET level achieved corresponds to a significant difference from the first year to the 10th year ($p < 0.01$) and a sustained MET level of over 9 from the third year to the ninth year (Fig. 3). This 9-MET level is equivalent to playing racquetball, snowshoeing, swimming or bicycling at about 22.5 km/h.[21] Considering that the mean MET level from the first stress test was close to 7 METs, this means that there was an improvement of more than 2 METs in a year of participation in the program, and this was maintained over time.

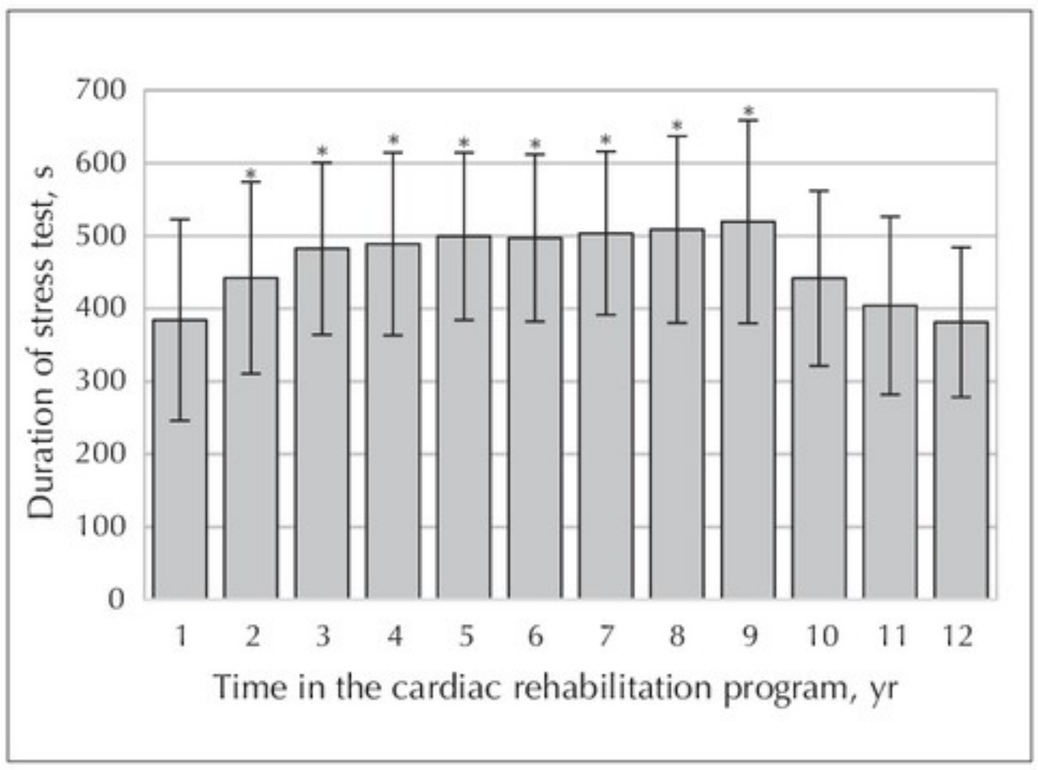

Fig. 1. Mean duration of stress test, by number of years in the program compared with year 1 as the baseline. *$p < 0.01$.

Table 2. Duration of stress test after the first year of participation in the cardiac rehabilitation program

Year	Age, mean, yr	No.	Duration, s; mean ± SD	Difference from year 1, %
1	66	85	384 ± 138	–
2	66	85	442 ± 132	15
3	67	73	483 ± 118	26
4	67	63	489 ± 126	27
5	68	54	499 ± 115	30
6	69	46	497 ± 115	29
7	69	37	504 ± 112	31
8	69	34	509 ± 128	32
9	70	31	519 ± 139	35
10	71	28	442 ± 120	15
11	71	26	404 ± 122	5
12	72	23	381 ± 103	–1

Blood pressure and heart rate

Measurements of pretest and peak blood pressure and heart rate indicate that there was a nonsignificant change in all measures over the course of program participation. Table 3 shows pretest and peak heart rate measurements over time and demonstrates a typical minor increase with aging for most measurements.[22,23] These levels are confounded by medication taken to control for high blood pressure and heart rate abnormalities, but the general trend exhibits stable systolic and diastolic blood pressure, heart rate and rate-pressure product measures at both pretest and peak levels.

DISCUSSION

Patients who participated in the cardiac rehabilitation program over long periods (> 1 yr) achieved longer stress test durations and peak estimated MET levels than they achieved at program entry. Long-term participants also maintained stable resting and peak blood pressure and heart rate measurements, even after experiencing recurring cardiovascular events and orthopedic challenges. Our results demonstrate that long-term participation in a cardiac rehabilitation program is associated with these benefits and that the benefits can be maintained for more than a decade. It is possible, even in a rural setting, to develop and sustain a cardiac rehabilitation program that encourages long-term participation.

Most participants in cardiac rehabilitation programs at other centres complete between 6 weeks

and 18 months, depending on the program, and are sent back to attempting regular exercise without clinical supervision.[6,17,23,24] The finding that staying in a clinically supervised program prolongs the ability to sustain MET levels suggests that the third phase (the 6–18 mo program) and ultimately the fourth phase (the independent exercise program) of reintegration back to nonclinically supervised independent exercise should be reconsidered. Long-term participation in clinically monitored classes was found to encourage regular involvement in physical activity. This sustained MET level achieved continuity of health benefits beyond that seen in other published research on cardiac rehabilitation programs to date. Further research is required to understand the reasons the program encouraged participants to stay motivated for this long duration. In addition, research should investigate why there is a gradual reduction in duration after the ninth year.

The proportion of women experiencing cardiovascular events that make them eligible for these programs is known to be greater than the proportion of men, but female participation rates are historically low.[25] This study corroborates this finding, with men outnumbering women 3 to 1. Future research should determine the barriers experienced by women, the removal of which may assist women in participation.

Most of the previous research reporting on health and physical activity after participation in a cardiac rehabilitation program for up to 12 weeks demonstrate an improvement in the patient's aerobic

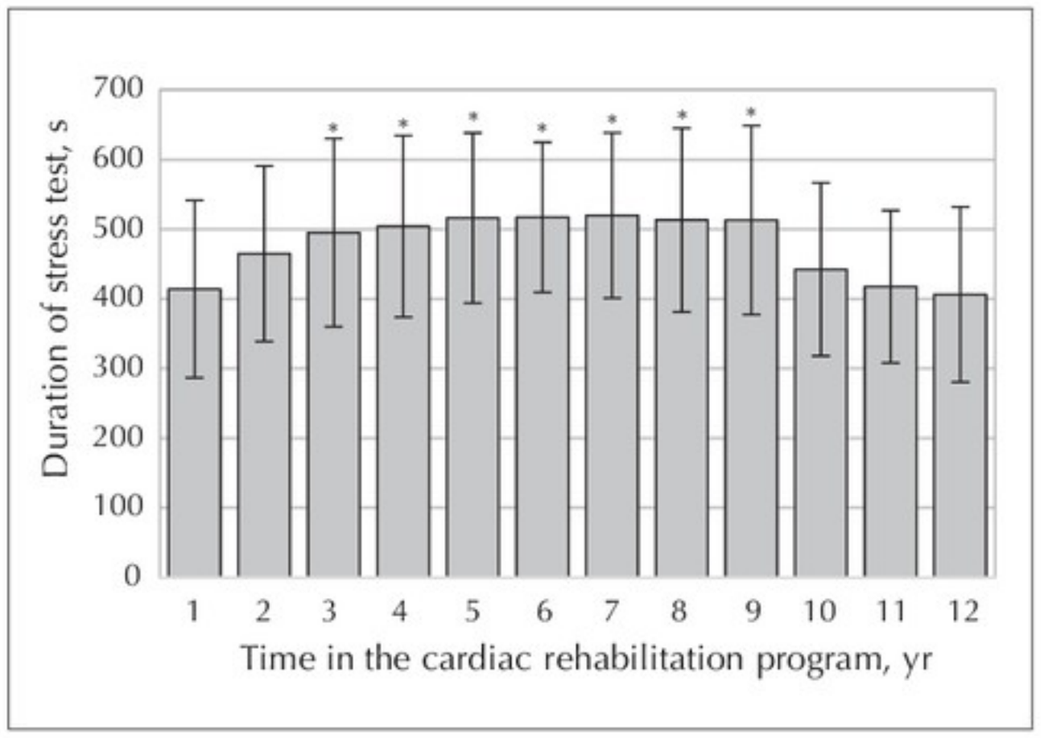

Fig. 2. Mean duration of stress test in participants with more than 10 years of program participation (n = 26), by number of years in the program compared with year 1 as the baseline. *p < 0.01.

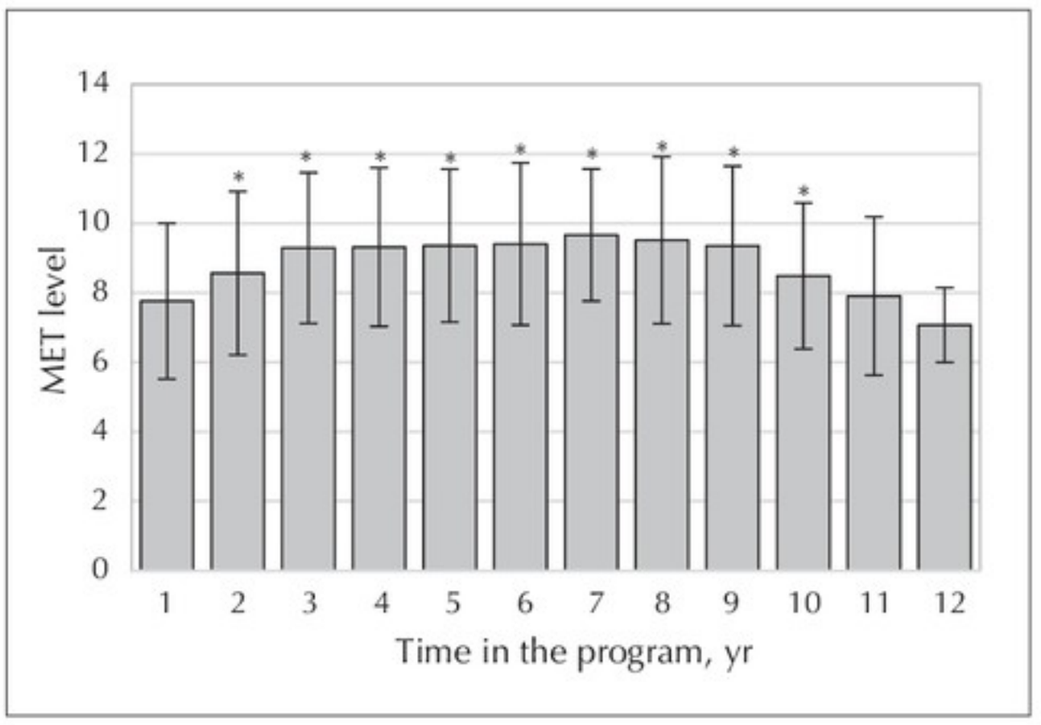

Fig. 3. Mean change in estimated MET level, by number of years in the program compared with year 1 as the baseline. *p < 0.01. MET = metabolic equivalent of task.

Table 3. Pretest and peak measurements of heart rate and blood pressure over time

	Heart rate, beats/min		Diastolic blood pressure, mm Hg		Systolic blood pressure, mm Hg		Rate-pressure product	
Year	Pretest	Peak	Pretest	Peak	Pretest	Peak	Pretest	Peak
1	66	123	74	77	126	165	83	205
2	65	122	73	77	124	166	80	203
3	66	126	73	77	125	172	82	218
4	66	124	73	76	125	165	82	206
5	65	124	73	80	125	167	81	209
6	65	125	76	79	128	168	83	212
7	66	125	73	78	128	169	84	213
8	66	127	74	78	127	172	84	221
9	68	127	75	79	134	171	92	220
10	70	130	77	80	131	165	92	219
11	68	122	74	77	133	162	91	199
12	74	124	79	78	135	168	100	206

capacity at the end of the program and relatively stable but declining aerobic capacity for the 2 years studied after the end of the program.[4] However, it is known that long-term participation in leisure-time physical activity 12 years after a myocardial infarction reduces the risk of death by half when compared with inactive patients, irrespective of habits before myocardial infarction.[6] This rural cardiac rehabilitation program is an example of what people will choose to do given the option of staying in a program after experiencing a cardiac event.

What is the explanation for most patients reducing exercise or becoming inactive after participation in a cardiac rehabilitation program? Some researchers have suggested that barriers to participation such as travel, physical health and personal or family problems are a reason for stopping participation.[13,15] This struggle to exercise is similar in any other person who is able-bodied or experiencing a disability.[13,15,26] However, in the current study, participants averaged 9 years or more in monitored classes, with some participants remaining in the program since its inception 18 years previously. Research on why participants do travel and enjoy the cardiac rehabilitation program would be beneficial.

It was the intent of this study to examine restorative and deteriorative health indicators of the participants. Because of numerous studies confirming improved physical conditioning and health outcomes, some results were anticipated, such as stable pretest and peak rate-pressure product, blood pressure and heart rate. In this study, we found a restorative health result over a 9-year period. Long-term participation in a clinically supervised cardiac rehabilitation program is likely to result in the maintenance of benefits observed in physiologic markers as well as a reduction in cardiovascular morbidity and mortality. To confirm this observation would require a prospective, randomized trial with intention-to-treat follow-up of participants and dropouts.

What might be important to consider, particularly in a rural community with limited resources, is the benefit of physical activity in preventing or slowing the trajectory of other chronic diseases. Booth and colleagues,[27] in a very extensive literature review of 35 chronic diseases, concluded that lack of physical activity was a causal factor. These chronic diseases, which are most prevalent in older adults, include colon and breast cancer, diabetes, osteoporosis, balance problems and falls, rheumatoid arthritis and stroke. Therefore, maintaining attendance in a cardiac rehabilitation program beyond the normal time frame may have a myriad of benefits and potentially be a very cost-effective way to treat other chronic conditions. In a rural community where there may be the resources for only 1 exercise program, it may be advisable not only to encourage cardiac patients to continue, but also to invite other older adults to join as well. The program described here is potentially an important resource in the treatment of many other conditions.

Limitations and strengths

The most obvious limitation was that there were no control groups. In addition, researchers conducting retrospective studies cannot control exposure or outcome assessment because other individuals have completed the record keeping. It is fortunate that this study minimized the recorded outcome and stress test stop time exposure by using the same physician to conduct the stress tests over most of the study period. There was also continuity of clinical instructors over the course of the program.

Samples and sample sizes across time differed in this study owing to a variety of entry points into the program. This meant that a true repeated-measures design was not possible. A Wilcoxon signed-rank test using a p value of 0.01 for tests of significance was performed on data to offset this heteroscedasticity.

One last area that was out of the control of researchers was the medication effect on stress test outcome variables. The pilot study showed that there was no record of medication compliance over time nor was there an analysis technique that could control for medication use.

The strengths of this study and program are numerous. The program leaders and medical director have served for more than 15 of the 20 years the program has been in existence. Clinical instructors remained consistent and the class has been held in the same recreation facility for 15 of the 20 years, creating an atmosphere that encourages health and well-being.

CONCLUSION

Participants in the cardiac rehabilitation program demonstrated improved duration of stress testing, and stable rate-pressure product, blood pressure and resting heart rate during long-term participation in the program. Lack of exercise is a major cause of chronic disability.[27] Long-term clinically supervised cardiac rehabilitation programs are beneficial in improving aerobic fitness levels beyond the typical program duration of 6 weeks to 18 months.

Benefits of stabilized heart rate and blood pressure markers as well as typical laboratory measures can be maintained for many years. This rural program is a model for others, including governments, to emulate and support. With limited resources, rural communities struggle to maintain health promotion and rehabilitation programs. This study reports on a success story that is perhaps worth emulating in other communities.

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Competing interests: None declared.

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