

# The Feasibility of Implementing Aerobic Interval Training in Cardiac Rehabilitation Settings: A Retrospective Analysis

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## Research article

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# Abstract

**Background:** Cardiovascular disease is the leading cause of death worldwide. Notwithstanding the well-known benefits of cardiac rehabilitation (CR), adherence to CR remains low, particularly in women. Aerobic interval training (AIT) has received specific attention as an emerging exercise-training paradigm that addresses frequently cited barriers to CR (i.e. lack of motivation/enjoyment and time, perceiving exercise regime as tiring/boring) and improves cardiovascular risk factors. Previous studies have examined the safety of AIT in CR settings; there is little evidence on the feasibility of AIT in CR. The aims of this study were to evaluate the feasibility of AIT within a CR setting and examine the sex differences regarding the feasibility of such programming.

**Methods:** Patients attended an on-site AIT CR program (10-minute warm-up, 25 minutes of interspersed high [HI - 4 minutes at 85-95% HRpeak] and low [LO - 3 minutes at 60-70% HRpeak] intervals, 10-minute cool-down) twice weekly for 10 weeks. Heart rate (HR) and the Borg rating of perceived exertion (RPE) scale were recorded at each session. Feasibility was assessed by: (1) attendance and compliance: the number of sessions attended and the compliance to the prescribed HI and LO HR ranges; (2) the patient experience: patients' perceived effort, program difficulty, if the program was challenging and satisfying; and, (3) safety. Descriptive statistics were used to report the means and their variations. Mann-Whitney U tests and Chi-square analyses were performed to examine sex-differences.

**Results:** A total of 160 patients (33% women, 67% men,  $57.2 \pm 9.6$  years) attended the AIT program and completed  $16 \pm 5$  classes with a low attrition rate (11.3%). Most patients met or exceeded the prescribed target HR for the HI (80%) and LO (84%) intervals, respectively. Patients reported a "somewhat hard" RPE for HI ( $14 \pm 1$ ) and "very light" for LO ( $10 \pm 2$ ) intervals. All patients were satisfied with the program and found it challenging. Most patients found AIT to be difficult ( $7 \pm 2$ ), yet safe (97%). Three vasovagal episodes occurred and more women dropped-out of the program than men ( $p < 0.01$ ).

**Conclusions:** AIT is a feasible, safe and well-received exercise paradigm in a CR setting.

## Introduction

Cardiovascular disease (CVD) is the leading cause of death worldwide (1). Following a cardiovascular event, participation in exercise-based cardiac rehabilitation (CR) is recommended; such programs improve functional capacity, enhance psychological health and reduce cardiovascular mortality (2). Despite the well-known benefits of participation in CR, adherence rates are low, particularly among women (3). Patients report a number of barriers to participating in traditional CR including poor self-efficacy, low motivation, and time constraints (4). Given the low attendance rate in traditional CR programs (mean:  $66 \pm 18\%$ , range: 37–85% session attendance) (5), there is a need to examine the feasibility of other innovative exercise programs within CR settings.

There is growing interest in implementing aerobic interval training (AIT) in CR settings given the significant cardiovascular health improvements observed in adults with coronary artery disease (6–9)

and heart failure (10,11) when compared to traditional CR. AIT consists of repeated bouts of high-intensity exercise interspersed with lower intensity active/passive periods of recovery (12). AIT is an appropriate exercise paradigm for CR settings; current American, Canadian and European CR guidelines (13) recommend the prescription and progression of moderate to vigorous intensity aerobic exercise. Despite evidence that suggests AIT is safe for adults with CVD (14,15), concerns remain regarding the feasibility of AIT in CR (16). This can be examined by assessing the attendance, compliance, and experience of patients and monitoring adverse events (safety) to determine if such programs are appropriate for 'real world' settings (17). The majority of clinical trials to date, while providing brief statements on the attendance, compliance, drop-out rates and adverse events experienced with AIT (7,8,18,19), have inadequately reported these parameters. Some investigators, for instance, simply reported the mean intensity at which individuals exercised during AIT (8,18) while others noted only the compliance to the high- and low-intensity sessions, respectively (20,21). No studies to date have comprehensively evaluated the patient's perspective on the experience, satisfaction and safety with AIT. Clinicians, as a consequence, lack the information which would allow them to determine the feasibility of introducing such programs to their patients. It is clear that more detailed reporting on the adherence to AIT in a CR setting is needed.

Fewer women attend CR (ratio of sessions attended to those prescribed) than men (mean difference: 3.4%, 95% confidence intervals: -6.9 to -0.3%,  $p = 0.03$ ) (5), it is important to determine which exercise programs may be most appealing to them. To date, studies that have examined the effects of AIT on cardiovascular health in adults with CVD have involved predominantly men (22). A recent women-only AIT study by Reed et al. demonstrated greater clinically meaningful mental health improvements with AIT when compared to moderate-to-vigorous intensity continuous exercise (2). Further, Terada et al. found that women in CR experienced greater reductions in anxiety severity with AIT ( $-1.7 \pm 2.7$  vs.  $-0.4 \pm 2.8$  points,  $p = 0.036$ ); yet men had larger improvements with moderate-to-vigorous intensity continuous exercise (23). This provides promising evidence for the use of AIT for women and underscores the importance of formally examining the impact of such programs for cardiac patients.

The principal purpose of this study was to conduct an exploratory retrospective analysis of the feasibility (as defined by the attendance, compliance, patient experience and safety) of an AIT program in patients attending CR. The secondary purpose was to explore sex differences regarding the feasibility of such a program in CR.

## Methods

### Study design

This was a retrospective mixed-methods analysis to evaluate the feasibility of AIT in CR settings. Ethics approval for this study was obtained from the Ottawa Health Sciences Network Research Ethics Board (Protocol #: 20170721-01H). This study was conducted in line with the Declaration of Helsinki.

### Participants

Patients were referred by a physician or nurse practitioner in the community or using an automatic referral process at the University of Ottawa Heart Institute (UOHI), to an on-site CR program at the UOHI between January 2014 and May 2019. Eligible participants were those who: (i) had a baseline exercise level  $\geq 4$  metabolic equivalents (METs [ $\geq$  walking pace of 4.0 mph]); (ii) did not have contraindications for participating in high-intensity exercise; (iii) were able to sustain at least 30 minutes of aerobic exercise; and, (iv) were able to independently self-monitor and report responses during exercise sessions.

## Aerobic Interval Training

Participants attended an AIT class led by a CR Physiotherapist (MLK) twice weekly for 10 weeks in the Cardiac Prevention and Rehabilitation Centre at the UOHI. The 45-minute classes followed a modified Norwegian AIT protocol (10) which consisted of: (i) a 10-minute warm-up at 60–70% peak heart rate ( $HR_{peak}$ ); (ii) 4  $\times$  4-minutes of high-intensity intervals at 85–95%  $HR_{peak}$  interspersed with 3 minutes of lower intensity intervals at 60–70%  $HR_{peak}$ ; and, (iii) 10-minute cool-down at 60–70%  $HR_{peak}$  with resistance and stretching exercises. Peak HR was determined by a graded exercise testing (GXT). In cases where GXT data was not available,  $HR_{peak}$  was estimated using the Gelish formula:  $207 - (0.70 \times \text{age})$  (24). For those taking  $\beta$ -blockers, 30 bpm were subtracted from their estimated peak HR to address the HR blunting effect of these medications (24).

Individuals were provided the option to complete AIT using: (i) aerobic exercise equipment (treadmill, cycle ergometer, elliptical, etc.) or (ii) dance/movement-based routines. All participants, regardless of exercise choice, completed the AIT with musical accompaniment of a tempo appropriate for high or lower intensity training. The initial two weeks of the 10-week program were designed to allow the participants to familiarize themselves with the AIT protocol. Participants monitored their exercise HRs using Polar HR monitors (Polar RS800CX, Polar Electro Oy, Kempele, Finland) or HR values displayed on aerobic exercise equipment. For individuals using Polar HR monitors, values were displayed on a television in front of the participants in the Polar Team iPad application.

Participants were instructed to keep their HR within the appropriate target training range (i.e. 85–95% peak HR or 60–70% peak HR dependent on the interval), and to adjust movement or workload to stay within these exercise-intensity target ranges. Participants were encouraged to attain a Rating of Perceived Exertion (RPE) (6–20 scale) (25) of 15–17 (“hard to very hard”) during the high-intensity intervals and 11–13 (“light to somewhat hard”) during the low-intensity intervals. At the end of each session, participants received a 5-minute educational talk addressing the self-management of CVD (e.g. physical activity, diet, medications and stress-management).

## Outcome Measures

### Feasibility

To assess the feasibility of AIT in CR, exercise, exercise attendance, compliance, the patient experience and safety were examined.

# Exercise Attendance and Compliance

Exercise attendance was assessed by the number of classes participants attended. High attendance to the CR program and AIT protocol was defined as being present at  $\geq 70\%$  of the classes. Exercise compliance was assessed as the ability to complete the prescribed intensity for the high (HI) and lower (LO) intervals. The HRs across all classes for the HI and LO intervals for each individual were averaged and compared to their target HR prescription. For instance, where patients exercised below, within or above the prescribed HR ranges, these were coded as “does not adhere”, “adheres to HI/LO” and “exceeds HI/LO”.

## Patient Experience

Participants were asked, upon program completion, to complete a feedback questionnaire which comprised of 20 questions regarding their experience with AIT. The questionnaire was developed by scientists and clinicians involved in CR at the UOHI. For the purposes of this study, we analyzed questions regarding exercise intensity using a 10-point Likert scale with “0” being “not difficult at all” to “10” being “extremely difficult; if AIT was challenging using a Yes or No question, and program satisfaction using a Yes or No question. To further assess exercise intensity, RPEs across all classes for the HI and LO intervals, respectively, were averaged.

## Safety

Safety was assessed by enumerating reported adverse events during the study period and the response to a single question regarding the participant’s perceptions of the safety of the program through a Yes or No question.

## Qualitative Data

The feedback questionnaire also comprised open-ended questions regarding the AIT program. The questions that were analysed for themes associated with the attendance, compliance, patient experience and safety were: (i) : “Satisfied with the program and would recommend to others”; (ii) “Favourite part of the program”; and, (iii): “Additional comments or concerns”. Data analysis was undertaken using an inductive thematic analysis approach. This involved identifying repeated comments/experiences that were described by patients and coding these responses to determine themes.

## Estimated Cardiorespiratory Fitness

A symptom-limited GXT on a treadmill using an individualized ramp protocol (i.e. treadmill stress test) was completed at baseline and following the CR program by cardiac stress technologists in the Department of Cardiac Imaging at the UOHI. The ramp protocol involves walking or jogging at a constant speed (e.g. 2.0, 3.0, or 4.0 mph) dependent on participants’ functional abilities with a 1.7% increase in grade every minute until volitional fatigue is achieved. HR was measured throughout the test using an electrocardiogram. Estimated peak exercise capacity ( $\dot{V}O_{2peak}$ ) was calculated using the ACSM Walking

equation which takes into consideration the speed and grade reached in the final stage of the test:  $\dot{V}O_2$  peak (mL/kg/min) = Final speed (m/min) x 0.1 + final grade x final speed (m/min) x 1.8 + 3.5 (24).

## Participant Characteristics

Research assistants extracted demographic and clinical information from the CR clinical database including age, ethnicity, marital status, education, smoking status, medication use and cardiovascular diagnoses.

### Anthropometry

Height was measured to the nearest 0.5 cm, body mass was measured to the nearest 0.1 kg, and body mass index (BMI) was calculated ( $\text{kg}/\text{m}^2$ ). Waist circumference was measured to the nearest 0.5 cm at the midpoint between the lower costal margin and iliac crest while participants stood with arms at their sides, feet 25–30 cm apart and abdomen relaxed.

### Resting Blood Pressure and Heart Rate

Resting blood pressure and HR were measured using an automated blood pressure monitor (Bp-TRU, Canada; or, Welch Allyn, Canada) by CR staff at baseline and following the CR program. These measures followed standardized procedures (24).

### Statistical Analysis

Analyses were performed using SPSS for Windows (Version 26; IBM Corp, Armonk, NY, USA). All outcome variables were tested for normality using Shapiro-Wilk tests. For feasibility outcomes, descriptive statistics were used to describe the attendance, compliance, patient experience and safety. To assess sex-differences in participant characteristics and feasibility outcomes, independent t-tests and Mann-Whitney U tests were used for continuous variables for normally distributed and non-normally distributed data, respectively. Chi-square tests were used for categorical variables. Data are reported as means  $\pm$  standard deviations, unless otherwise noted, and  $p < 0.05$  was considered statistically significant.

## Results

### Participants

Descriptive data for the participants are shown in Table 1. Most (> 70%) participants were Caucasian, married and non-smokers. On average, participants were overweight, normotensive (due to medical management), with a high-risk waist circumference ( $\geq 90$  cm). Most (> 50%) were taking anti-platelets,  $\beta$ -blockers, anti-dyslipidemics and ACE inhibitors. Of the individuals who participated in AIT, 67 patients (31% women, 69% men) completed the feedback questionnaire.

Table 1  
Participant Characteristics

	Total N = 160	Women N = 53	Men N = 107	P value (sex difference)
Demographics, mean ± SD / n (%)				
Age (years)	57.2 ± 9.6	57.6 ± 9.3	57.1 ± 9.8	0.749
Sex (% men)	107 (67)	-	-	-
Ethnicity (% Caucasian)	133 (86)	42 (84)	91 (88)	0.454
Marital status (% married)	119 (77)	34 (68)	85 (81)	0.281
Education (% four years College/University)☒	75 (49)	21 (43)	54 (51)	0.105
Smoker (%)☒	10 (6)	2 (4)	8 (7)	0.661
Physical Measures, mean ± SD				
Height (cm)☒	171.8 ± 9.5	161.8 ± 5.2	176.4 ± 9.8	0.000**
Body mass (kg)	82.4 ± 16.7	71.4 ± 15.5	87.5 ± 14.7	0.000**
BMI (kg/m <sup>2</sup> )☒	27.9 ± 4.9	27.3 ± 5.9	28.2 ± 4.3	0.279
Waist circumference (cm)☒	97.2 ± 12.3	91.2 ± 13.6	100.0 ± 10.7	0.000**
Resting systolic blood pressure (mmHg)	123 ± 15	124 ± 16	122 ± 15	0.577
Resting diastolic blood pressure (mmHg)	75 ± 9	57.1 ± 9.8	62 ± 9	0.982
Resting heart rate (bpm)	65 ± 12	70 ± 14	62 ± 9	0.000**
VO <sub>2peak</sub> (mL/kg/min)☒	32.5 ± 6.9	27.8 ± 6.2	34.7 ± 6.2	0.000**
Medications, n (%)				

Abbreviations: ACE, angiotensin-converting enzyme; BMI, body mass index; CABG, coronary artery bypass graft; PCI, percutaneous coronary intervention; SCAD, spontaneous coronary artery dissection; TIA, transient ischemic attack; VO<sub>2peak</sub>, estimated peak exercise capacity. \* Significant difference between sexes (p < 0.05). \*\*Significant difference between sexes (p < 0.01). ☒ Missing data. <sup>a</sup> Fisher's Exact test in instances where > 20% of cells have an expected count of < 5. Values are presented as means ± standard deviations or frequency (%).

	Total N = 160	Women N = 53	Men N = 107	P value (sex difference)
Anti-platelets	147 (92)	43 (81)	104 (97)	0.001*** <sup>a</sup>
β-blockers	113 (71)	30 (57)	83 (78)	0.006**
Anti-dyslipidemics	134 (84)	32 (60)	102 (95)	0.000**
ACE inhibitors	87 (54)	24 (45)	63 (59)	0.104
Angiotensin-receptor blockers	11 (7)	5 (9)	6 (5)	0.508 <sup>a</sup>
Calcium channel blockers	22 (14)	8 (15)	14 (13)	0.728
Anti-coagulants	17 (11)	7 (13)	10 (9)	0.456
Anti-depressants	15 (9)	8 (15)	7 (7)	0.091 <sup>a</sup>
Anti-diabetics	12 (8)	4 (8)	8 (7)	1.000 <sup>a</sup>
Anxiolytics	4 (3)	1 (2)	3 (3)	1.000 <sup>a</sup>
Cardiovascular History n (%)				
Coronary artery disease	118 (74)	27 (51)	91 (85)	0.000**
Angina	18 (11)	8 (15)	10 (9)	0.279
Arrhythmias	22 (14)	7 (13)	15 (14)	0.888
Ablation	2 (2)	1 (2)	1 (1)	1.000 <sup>a</sup>
Valvular disease	19 (4)	10 (19)	9 (8)	0.054
Stroke/TIA	5 (3)	3 (6)	2 (2)	0.333 <sup>a</sup>
SCAD	1 (1)	1 (2)	0 (0)	0.331 <sup>a</sup>
Heart Failure	3 (2)	2 (4)	1 (1)	0.255 <sup>a</sup>
PCI	93 (58)	21 (40)	72 (67)	0.001**
CABG	27 (17)	1 (2)	26 (24)	0.000**
PCI + CABG	7 (4)	0 (0)	7 (6)	0.096 <sup>a</sup>

Abbreviations: ACE, angiotensin-converting enzyme; BMI, body mass index; CABG, coronary artery bypass graft; PCI, percutaneous coronary intervention; SCAD, spontaneous coronary artery dissection; TIA, transient ischemic attack;  $\dot{V}O_{2peak}$ , estimated peak exercise capacity. \* Significant difference between sexes ( $p < 0.05$ ). \*\*Significant difference between sexes ( $p < 0.01$ ). ☐ Missing data. <sup>a</sup> Fisher's Exact test in instances where  $> 20\%$  of cells have an expected count of  $< 5$ . Values are presented as means  $\pm$  standard deviations or frequency (%).

	Total N = 160	Women N = 53	Men N = 107	P value (sex difference)
Primary Prevention	5 (3)	4 (8)	1 (1)	0.042* <sup>a</sup>
Abbreviations: ACE, angiotensin-converting enzyme; BMI, body mass index; CABG, coronary artery bypass graft; PCI, percutaneous coronary intervention; SCAD, spontaneous coronary artery dissection; TIA, transient ischemic attack; $\dot{V}O_{2peak}$ , estimated peak exercise capacity. * Significant difference between sexes ( $p < 0.05$ ). **Significant difference between sexes ( $p < 0.01$ ). ☐ Missing data. <sup>a</sup> Fisher's Exact test in instances where $> 20\%$ of cells have an expected count of $< 5$ . Values are presented as means $\pm$ standard deviations or frequency (%).				

Men were taller, had greater body mass, waist circumference,  $\dot{V}O_{2peak}$  and lower resting HR than women ( $p < 0.05$ ). Further, more men were taking anti-platelets,  $\beta$ -blockers, anti-dyslipidemics and ACE inhibitors when compared to women ( $p < 0.05$ ). More men suffered from coronary artery disease and had undergone a surgical intervention (i.e. percutaneous coronary intervention or coronary artery bypass graft) ( $p < 0.05$ ). Significantly more women participated in CR for the primary prevention of CVD than men. There were no other significant differences in demographics, anthropometrics, physical measures, medication use or cardiovascular conditions observed between men and women ( $p > 0.05$ ).

## Feasibility Outcomes

### Exercise Attendance and Compliance

On average, participants attended  $16 \pm 5$  AIT classes, with most patients (72%) completing  $\geq 70\%$  of the classes. Most participants were able to meet (HI: 53.4%, LO: 41.5%) or exceed (HI: 27.0%, LO: 42.2%) the target HR ranges for the HI and LO intervals, respectively (Figs. 1 and 2). While there was a low attrition rate (11.3%), significantly more women dropped-out of the program than men ( $p < 0.01$ , Table 2). No sex differences were found for class attendance and compliance with the exercise prescription ( $p > 0.05$ ).

Table 2  
Feasibility Outcomes

	All N = 160	Women N = 54	Men N = 106	P value (sex differences)
Attendance and Compliance				
Classes Attended <sup>⊠</sup>	16 ± 5	15 ± 6	16 ± 5	0.066
Attended ≥ 70% of classes <sup>⊠</sup>	108 (72.0)	36 (67.9)	72 (74.2)	0.411
Dropouts <sup>⊠</sup>	18 (11.3)	11 (20.4)	7 (6.6)	0.009**
Compliance to HI <sup>⊠</sup>				0.935
Less than HI HR Target	29 (19.6)	10 (19.2)	19 (19.8)	
Within HI HR Target	59 (53.4)	27 (52.0)	52 (54.2)	
Exceeds HI HR Target	40 (27.0)	15 (28.8)	25 (26.0)	
Compliance to LO <sup>⊠</sup>				0.941
Less than LO HR Target	24 (16.3)	9 (17.3)	15 (15.8)	
Within LO HR Target	61 (41.5)	22 (42.3)	39 (41.1)	
Exceeds LO HR Target	62 (42.2)	21 (40.4)	41 (43.1)	
Patient Experience				
RPE HI <sup>⊠</sup>	14 ± 1	14 ± 2	14 ± 1	0.676
RPE LO <sup>⊠</sup>	10 ± 2	10 ± 2	10 ± 2	0.729
Difficulty of Class (0–10) <sup>⊠</sup>	7 ± 2	7 ± 1	7 ± 2	0.097
Challenging (Y/N) <sup>⊠</sup>	67 (100)	21 (100)	46 (100)	-
Satisfied with AIT (Y/N) <sup>⊠</sup>	66 (100)	16 (100)	50 (100)	-
Safe (Y/N) <sup>⊠</sup>	64 (97)	14 (87.5)	50 (100)	0.056 <sup>a</sup>
Abbreviations: AIT, aerobic interval training; HI, high-intensity; HR, heart rate, LO, lower-intensity; RPE, rating of perceived exertion; Y/N, yes/no. **Significant difference between sexes (p < 0.01). <sup>⊠</sup> Missing data. <sup>a</sup> Fisher's Exact test in instances where >20% of cells have an expected count < 5. Values are presented as means ± standard deviations or frequency (%).				

The qualitative data revealed that attending AIT classes was difficult if an individual did not live near the UOHI or have transportation to the classes (Table 3): E.g. "If I lived closer and had someone to get me there, I would not hesitate to attend and fully complete the program." Patients suggested that a local program may have improved their attendance: E.g. "Local program, such as in Cornwall or Alexandria

would be great! I live near Alexandria, so it is about 1 1/2 hour drive to The Heart Institute. Please let me know if there are local cardiac programs.”

Table 3  
Qualitative Analysis

Feasibility Outcomes	Common Themes
Higher Attendance and Compliance	Close Location for Classes
Positive Patient Experience	High Program Satisfaction Increased Confidence in Ability to Exercise Increased Social Interactions Enjoyment from High-Intensity Exercise
Increased Patient Safety	Supervision and Support from Staff Understanding Physical Capabilities and Limits Access to HR Monitoring
Abbreviations: HR, heart rate.	

## Patient Experience

On average, patients’ perceived exertion during the HI intervals as “somewhat hard” (RPE:  $14 \pm 1$ ) and “very light” (RPE:  $10 \pm 2$ ) during the LO intervals. Most patients found the intensity of the AIT class difficult ( $7 \pm 2$  [scale range: 0 to 10]). All patients found AIT challenging and were satisfied with the program. No sex differences were found for any patient experience outcomes (i.e. perceived exertion, intensity difficulty, challenging program, program satisfaction [ $p > 0.05$ ]).

The qualitative data showed that patients were satisfied with AIT and most individuals would recommend the program to other people: E.g. “Absolutely! I would recommend to anybody. It was a great way to exercise and have fun at the same time.” “I was very well satisfied with the program. I would most certainly recommend it highly to others.”

Some patients found the HI intervals (“the high-intensity portions”) and “getting the heart rate up and working hard with others” was their favourite part of the program.

The social aspect of the AIT classes was a common theme amongst patient responses which enhanced their experience: E.g. “Looking forward to seeing the instructors and everyone at the centre.” “The people - honestly I’ll miss the routine of seeing everyone 2/week.” “Being part of a group is like being part of a team. You must do it and that is good. Necessary!”

Patients also reported they were more confident in their ability to exercise: E.g. “Gaining confidence in being able to move around/exercise/get my HR up. This was achieved by being pushed and urged to work out harder.” “I came into the program feeling very insecure with my AFIB diagnosis, not knowing how much I could do in terms of returning to exercise and my confidence has been restored... I’m back at my gym.”

# Safety

Three vasovagal episodes were reported during the AIT program. Ninety-seven percent of patients reported the program to be 'safe' at all times.

The qualitative data showed that patients felt safe during classes because of the supervision and support they received from staff: E.g. "I couldn't feel safer - In fact I wish I could stay!" "The personal attention given to each person and the real concern everyone had with us." "The program provides individual treatment and personalized care for each patient."

Patients also felt AIT was within their physical capabilities and "knowing my (their) capabilities and limits": E.g. "It was a good way to improve my fitness level but still have the confidence that it was tailored to my circumstances." "The ease of acceptance of your physical abilities at the beginning, very motivating + motivated instructors." "The empathy and support from leaders was top shelf. They also pushed me to push my heart into vigorous territory which I wouldn't have done without their expertise."

Further, HR monitoring was another aspect of safety that patients appreciated: E.g. "Heart monitor was very helpful." "Really like the heart rate/% display on screen. Very helpful in reinforcing awareness of exertion levels."

## Discussion

This study is the first, to our knowledge, to provide a comprehensive evaluation of the feasibility of AIT in CR settings. In this retrospective mixed-method analysis, we found that most patients attended  $\geq 70\%$  of the scheduled AIT classes and were able to exercise at the prescribed HI and LO target HR ranges. Interestingly, most patients found the AIT program difficult and classes challenging. Yet, all participants reported that they were satisfied with AIT. Adverse events were rare (0.0012% occurrence) and the majority of patients perceived the classes to be safe. Our sex-based comparisons revealed that more women dropped-out of the AIT program than men. For all other outcomes, there were no significant sex differences. Our findings show that AIT appears to be a feasible and well-tolerated exercise paradigm for patients undergoing CR.

While there have been some investigations demonstrating low attendance with AIT (8,20), most studies have reported high attendance ( $\geq 70\%$  of the scheduled sessions) with AIT in cardiac patients (7,18,19,21,26). Specifically, Moholdt and colleagues revealed that individuals in an AIT program (4 × 4 minutes at 85–95% HR<sub>max</sub> with 3-minute active recoveries at 70% HR<sub>max</sub>, two supervised sessions and one home session per week) attended 57% of the CR classes offered across a 12-week intervention (8). Aamot et al. found significantly lower attendance with home exercise AIT (4 × 4 minutes at 85–95% HR<sub>max</sub> with 3-minute active recoveries at 70% HR<sub>max</sub>, twice a week for 12 weeks) when compared to supervised treadmill or group AIT sessions ( $p < 0.05$ ) (20). Given our program implemented supervised exercise sessions, this may explain our high attendance rates. Interestingly, most studies have not

reported on the compliance to AIT protocols (7,8,19,26). One study by Kim and colleagues reported that cardiac patients spent 86% of their exercise sessions within the target HR ranges with AIT (21). We similarly observed that most patients were able to meet or exceed the prescribed target HR for the HI (80%) and LO (84%) intervals, indicating that cardiac patients were able to comply with AIT. Our qualitative data revealed that some patients found the location (i.e. an inconvenient/long distance) of the classes reduced their attendance. This is consistent with previous findings showing that when CR offerings are not easily accessible or convenient, it may be a barrier to cardiac patient participation (27). Given our high attendance, other community exercise programs may consider implementing AIT for those with CVD.

Practitioners may be hesitant to prescribe AIT in CR as high-intensity exercise acutely increases the risk of myocardial infarctions and sudden cardiac death, particularly in sedentary individuals (28). Interestingly, we found that 27% of individuals exceeded the HI target HR range and very few adverse events occurred (3 out of 2,349 training sessions) with AIT. Our results are consistent with previous work indicating that adverse events are rare with AIT in cardiac patients. A recent systematic review (n = 23 studies) showed that major cardiovascular events were rare when implementing AIT in adults with coronary artery disease and heart failure with only one major cardiovascular event for 17,083 training sessions (14). Vasovagal syncope is more common within a CR setting due to the cardiovascular complications in this patient group (29). In response to the vasovagal episodes, we implemented a step-by-step reduction in the exercise intensity following the HI intervals. This was to ensure patients had a more gradual reduction in HR to avoid future events (29). No further vasovagal syncope episodes were reported. Our study supports previous work showing that AIT is safe in a CR setting (14,15) and the importance of a progressive reduction in HR following an AIT session. Practitioners involved in CR should be reassured that the risk of an adverse event is small in cardiac patients. Our qualitative data showed that supervision during the AIT classes helped patients feel safe and understand their physical abilities with exercise. Cardiac patients may not be aware of the low risk associated with AIT and major cardiovascular events.

There is limited evidence investigating the patient experience with AIT programs. Keteyian and colleagues implemented a similar AIT program in a CR setting and found that patients reported a mean RPE of 15 and 12 for the HI and LO intervals, respectively (26). We observed similar mean reported RPE during the HI ( $14 \pm 1$  points, "somewhat hard") and LO ( $10 \pm 2$  points "very light") intervals. A survey of 1,273 cardiac patients found that a barrier for patients attending CR was perceiving exercise to be tiring or painful (30). The integration of recovery periods in AIT serves to reduce the fatigue and discomfort experienced by patients during exercise. This may explain why patients in our study have a high attendance and satisfaction. To our knowledge, this is the first study to examine cardiac patient perception regarding AIT intensity difficulty; whether the program was challenging and satisfying for patients; and, the perceived patient safety of the program. Despite most patients finding the intensity of AIT difficult and completing the classes challenging, all patients reported that they were satisfied with AIT. Importantly, most patients thought AIT was safe to perform, challenging and increased their confidence in their ability to exercise. A common barrier to participating in CR is low self-efficacy (27). Given the individualized care and feedback that is often received in a supervised exercise program, patients can learn what their physical abilities are

when exercising at higher intensities and improve their self-efficacy. Further, the patient's experience with an exercise program is vital for predicting attendance (31). Our study highlights that AIT is well-received and an appealing exercise offering for cardiac patients which appears to lead to a positive patient experience.

The secondary aim of our study was to determine if there were sex differences in feasibility outcomes. While we did not observe any sex differences for most parameters, we found that significantly more women dropped-out of the AIT program than men. This finding is consistent with a large study in 1,088 women and 4,833 men with coronary artery disease who were enrolled in CR which found women to withdraw from CR more often than men (32). Further, we observed that more men were taking prescribed medications and had undergone an invasive procedure (percutaneous coronary intervention or coronary artery bypass) than women. These findings are unsurprising as men tend to receive more aggressive treatment for CVD than women (33–36). For instance, men receive more cardiac catheterizations (15.4% women, 27.3 men,  $p < 0.001$ ) or coronary artery bypass graft surgeries (5.9% women, 12.7% men,  $p < 0.001$ ) than women, despite women having greater functional disability with angina than men (35). Given that men are more likely to receive medications and surgical interventions for CVD, they may be more informed about their medical condition and understand the importance of attending CR. This may leave women with a lack of knowledge regarding the severity and management of CVD (37), which may influence their participation in CR programs. Our study reinforces the findings of previous work showing that there is a need to understand how to attract and improve the retention of women in CR.

There are limitations that warrant mention. While this is the first study examining the feasibility of AIT in cardiac patients, a retrospective mixed-methods analysis limits the ability to inform study design. For instance, we do not have the data to examine if patients complied to the duration of the HI and LO intervals. This was also a single centre trial, which may limit the generalizability of our results across other CR settings. Other aspects of the patient's experience should be explored such as patient confidence and self-efficacy to more thoroughly examine if AIT is feasible for this patient group. Similar to previous work (8,18–20,22,26), significantly more men participated in this study than women; the results from our sex analysis should, therefore, be interpreted with caution. Knowing the feasibility of an exercise provides valuable insight for practitioners who may wish to offer AIT for their cardiac patients but are unsure of the possible challenges with instructing AIT in this population.

## Conclusion

AIT is a well-received, safe and feasible exercise program within CR settings. All patients were satisfied with AIT and most individuals found the program to be challenging and improved their confidence to exercise. Sex-based analysis revealed that women were more likely to drop-out of AIT, however, there were no sex differences for all other feasibility outcomes (i.e. attendance, compliance, patient experience, safety). AIT is a suitable exercise modality for CR.

## List Of Abbreviations

ACE inhibitors, angiotensin-converting enzyme inhibitor; AIT, aerobic interval training; BMI, body mass index; CPET, cardiopulmonary exercise test; CR, cardiac rehabilitation; CVD, cardiovascular disease; HI, high-intensity interval; HR, heart rate;  $HR_{max}$ , maximum heart rate;  $HR_{peak}$ , peak heart rate; MET, metabolic equivalent; LO, lower-intensity interval; UOHI, University of Ottawa Heart Institute;  $\dot{V}O_{2peak}$ , estimated peak exercise capacity.

## Declarations

**Consent for publication:** Not applicable.

**Availability of data and materials:** The datasets during and/or analysed during the current study available from the corresponding author on reasonable request

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

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**Authors' Contributions:** KW and JR designed the study. KW drafted the manuscript. MLK delivered the exercise sessions. KW, SVA and HH completed data collection and verification. KW conducted statistical analysis and KW and JR interpreted the results. SVA, MJK, HH, AP and JR provided constructive feedback and edited the paper. All authors have given final approval for its publication.

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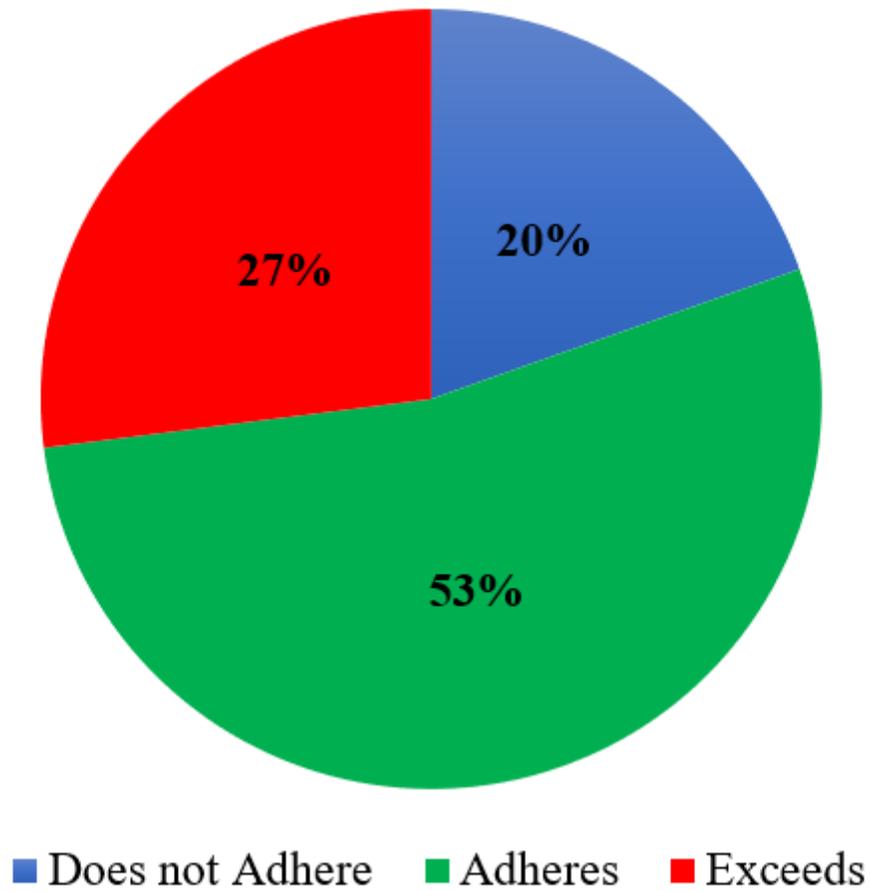
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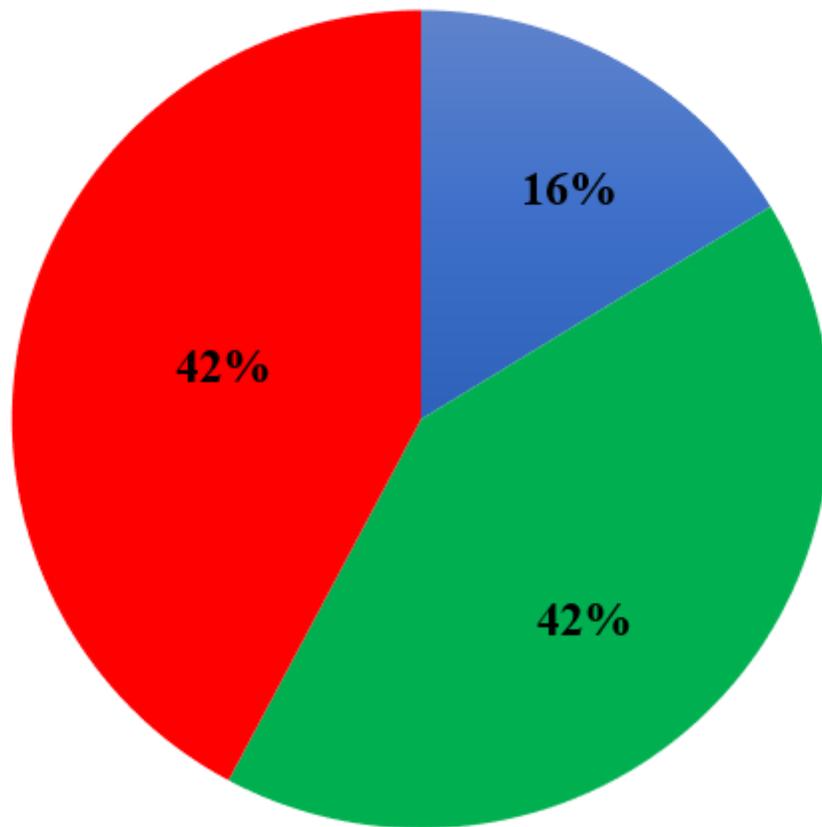
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## Figures



**Figure 1**

Adherence to the high-intensity intervals of the AIT protocol. “Does not adhere” refers to a mean HR range during classes < 85-95% HRmax; “Adheres” refers to a mean HR during classes with 85-95% HRmax; “Exceeds” refers to a mean HR range > 95% HRmax.



■ Does not Adhere   ■ Adheres   ■ Exceeds

**Figure 2**

Adherence to the lower intensity intervals of the AIT protocol. “Does not adhere” refers to a mean HR range during classes < 60-70% HRmax; “Adheres” refers to a mean HR during classes with 60-70% HRmax; “Exceeds” refers to a mean HR range > 70% HRmax.