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ORIGINAL ARTICLE

Adherence to Heart Rate Training Zones in an Exercise Training Program in Adults with Coronary Artery Disease

Patric Emerson Oliveira Gonçalves[1,*], Tiago da Silva Nogueira[2], Bruno Rezende Passos[2], Danielle Aparecida Gomes Pereira[2], Scott Thomas[3], Raquel Rodrigues Britto[2]

[1]*School of Kinesiology, The University of British Columbia, Vancouver, British Columbia, Canada.*
[2]*Cardiovascular and Metabolic Rehabilitation Center, Hospital das Clínicas, Universidade Federal de Minas Gerais, Belo Horizonte, Minas Gerais, Brazil.*
[3]*Faculty of Kinesiology and Physical Education, Toronto, Ontario, Canada.*

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KEYWORDS

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ABSTRACT

Objectives: To investigate the effect of exercise intensity on functional capacity in individuals with coronary artery disease, assess adherence to the heart rate training zone (HRTZ), and relationship between trained intensity and functional capacity.
Methods: Retrospective study led with medical records of 54 outpatients with coronary artery disease in a public hospital. The prescribed intensity started at 50 – 60% of heart rate reserve, increasing monthly to 70 – 80% by the third month. Spearman's test was used to assess the correlation between improvement in distance in the incremental shuttle walk test (ISWT), exercise intensity, and rating of perceived exertion (Borg-RPE). Adherence was classified as 'below' when HRTZ was not achieved in any phase of the program, 'intermediate' when HR was within the HRTZ for one or two months, and 'above' when HR was at or higher than HRTZ ≥ two months. Improvement was tested with t-test and one-way ANOVA.
Results: 51.9% of participants had an increase in ISWT of ≥70 m ($p < 0.0001$). In at least one month, 50.9% trained below HRTZ. Trained intensity did not go below 8.6% of the prescribed minimal threshold of HRTZ. Changes in ISWT were not significantly correlated with exercise intensity ($p = 0.87$) or Borg-RPE ($p = 0.16$).
Conclusion: While a significant increase in functional capacity was found, considerable heterogeneity in changes were observed. This may, in part, be related to adherence to HRTZ with progressive exercise intensity and to the variability in exercise volume in cardiovascular rehabilitation programs.

*Corresponding author:
Addr.: Medical Sciences Block C, 2176 Health Sciences Mall, Vancouver, British Columbia, Canada V6T 1Z3.
Phone: (604) 618-5404.
E-mail: patricog@alumni.ubc.ca (Gonçalves PEO)

The study was conducted at Hospital das Clínicas, Universidade Federal de Minas Gerais.

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INTRODUCTION

Exercise training is essential for restoring previous functionality and activity levels and preventing new cardiac events and is recommended as part of cardiovascular rehabilitation programs (CVR)[1,2]. Large cohort studies have found that exercise capacity strongly predicts mortality, myocardial infarction events, and downstream revascularization. In fact, even a 0.5-MET (metabolic equivalent) increase in exercise intensity capacity is associated with a lower mortality rate[3,4].

Studies have also shown substantial variability in exercise prescriptions among CVR centers[5,6]. Investigations of different prescribed parameters among professionals revealed significant variation in the duration, frequency, and prescribed intensity for the same patient with coronary artery disease[7].

Intensity plays a critical role in enhancing the conditioning response. However, there remains a gap in understanding why some individuals do not adhere to the prescribed heart rate training zone (HRTZ) during CVR sessions. Researchers have observed that in their outpatient CVR programs, 67% trained below the lower intensity threshold[8].

Not all patients referred to CVR programs are functionally capable of being subjected to a graded exercise test (GXT). Moreover, not all CVR programs in middle- or low-income countries can afford a GXT, which is why functional capacity tests such as the incremental shuttle walk test (ISWT) are fundamental[9].

If CVR participants do not achieve or sustain HRTZ, the exercise stimulus may be suboptimal, and consequently, improvements in functional capacity may be hindered[10,11].

Therefore, this study aimed to assess the actual training intensity relative to the prescribed HRTZ, changes in functional capacity following exercise training, and the relationship between training intensity and functional capacity.

METHODS

Study design

A retrospective study with data collected from the medical records of patients with coronary artery disease (CAD) at an outpatient CVR program. This study was approved by the Ethics and Research Committee of the Federal University of Minas Gerais (CAAE: 11020919.9.0000.5149, opinion number 3331.948, of 2019 May 17). Informed consent was waived given this study was a retrospective study.

Sample

The medical records of outpatients admitted to the CVR program at the Cardiovascular and Metabolic Rehabilitation Center of a public university institution, at Jenny de Andrade Faria Institute at the Hospital das Clínicas, Belo Horizonte, Minas Gerais, Brazil, were analyzed.

We included adults older than 18 years with CAD, post-myocardial infarction, or acute coronary syndrome with left ventricular ejection fraction ≥ 40% as assessed through a recent echocardiogram (< 6 months) by a trained cardiologist. To be eligible, participants had to be first-time participants in a CVR program, perform a GXT and a functional capacity test (i.e., incremental shuttle walking test) before and after the CVR program, and have attended at least ≥ 50% of the program. Individuals were excluded if they did not attend for two or more consecutive weeks or had another diagnosed cardiovascular disease.

Rehabilitation design

Participants initially underwent a history and physical examination by a cardiologist, followed by a GXT to guide exercise prescription[12]. Due to protocols for financial contingency, the GXT and not a cardiopulmonary test was performed at admission only, with a treadmill using a ramp or the Bruce protocol[13]. If the GXT had been reported as ischemic in participants with stable angina, heart rate peak (HRpeak) was defined as 10 bpm below the ischemic heart rate (HR)[14]. The three-month program was supervised by physical therapists, with exercise intensity prescribed as a percentage of the heart rate reserve (%HRR) using the Karvonen formula. In the first month of the program, participants performed supervised training 3x/week at 50-60% HRR, 2x/week at 60-70% HRR in the second month, and 1x/week at 70-80% HRR in the third month[15].

Each session lasted 50 min and comprised a 5-min warm-up, 30 min of aerobic training (treadmill, lower limb cycle ergometer, or a circuit training), 5-min cool down, and 10 min of resistance training. All participants were also instructed to perform unsupervised exercises to meet the exercise recommendation guidelines (150 min/week, and 2x/week of resistance training).

Measurements

Exercise intensity

Data were collected from the last session of each month in the CVR program to mitigate the early training adaptation bias from the initial sessions.

Heart rate was monitored using a chest heart rate monitor or with self-pulse oximeters and was recorded at rest while seated before exercise and 10 and 30 min during exercise to objectively assess exercise intensity. The modified Borg scale was used to assess exercise intensity subjectively[16,17].

Functional capacity

The ISWT assesses functional capacity, is validated for use in CVR programs, and is well correlated with maximal oxygen uptake and the Veterans Specific Activity Questionnaire (VSAQ), and both were completed at admission and discharge[18-20].

Statistical analysis

Sample characteristics are presented as mean ± standard deviation (SD) or median (IQR: 25th, 75th percentiles), according to data normality or percentage. The normality of the data was tested using the Shapiro-Wilk test. The independent variables were training intensity (i.e., mean HR achieved in sessions, expressed as a percentage of HRR) and mean perceived exertion (Borg-RPE). The dependent variable, functional capacity, was recorded through the walking distance, in meters, in the ISWT. Paired *t*-tests compared the distance walked after *vs.* before the CVR program. Spearman's correlation tests assessed the relationships between changes in ISWT and 1) the average exercise intensity expressed as a %HRR and 2) perceived exertion, as measured by RPE.

One-way ANOVA was used to test differences in ISWT between groups: below, intermediate, or above prescribed HRTZ. Adherence was classified as 'below' when the participant did not achieve, on average, prescribed HR in any phase of the program, 'intermediate' when it was within HRTZ for one or two months, and 'above' when HR was maintained at or higher than HRTZ for at least two months. The Bonferroni test was used for post hoc analyses. Alpha = 5% was used for significance. The analysis was performed using IBM SPSS Statistics for MacBook (Version 23.0, IBM Corp).

RESULTS

We screened 197 medical records, 54 of which completed the program, met the eligibility criteria, and were subsequently included in the study (Figure 1, Table 1).

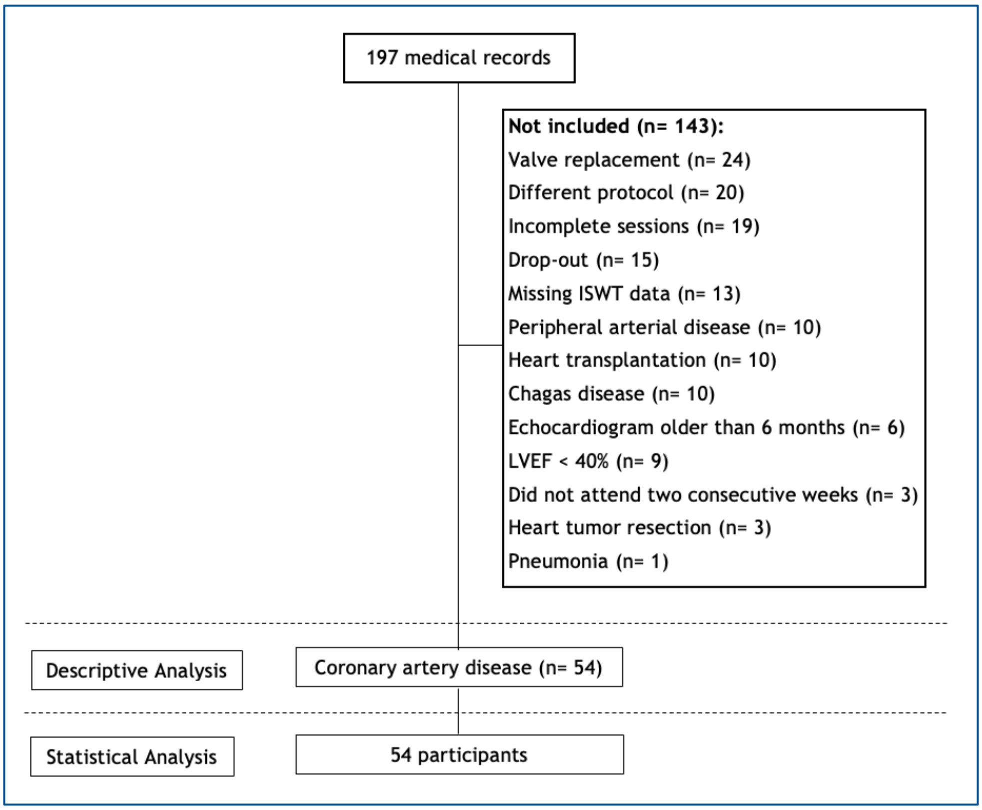

Figure 1 — Study participants flowchart. ISWT= incremental shuttle walking test. LVEF= left ventricle ejection fraction.

Overall, 50.9% of participants exercised below HRTZ for at least a month. Adherence to HRTZ decreased with increasing exercise intensity (Figure 2). No statistically significant difference in the between-groups analysis for distance walked in the ISWT was found (Table 2).

The average training intensity below the lower HRTZ threshold was 4.2%, 6.6%, and 8.6% in the first, second, and third months, respectively.

The average walked distance during the ISWT before the 3-month CVR program was 378.3 m (128.7) and 442.8 m (136.4) after (Figure 3). There was a median improvement in functional capacity of 70 m (10, 110), $p < 0.0001$ [39.4, 89.6], with 51.9% of patients showing a ≥ 70 m improvement in ISWT.

The results suggested low correlations between exercise intensity and changes in ISWT (rho = 0.02, p = 0.87), as well as between RPE and changes in ISWT (rho = 0.19, p = 0.16). The correlations when intensity was calculated as a percentage of the maximal HR reached during the GXT or for each phase of the program individually were also low. Outliers, defined as participants who did not fall within ± 2 SD of the mean, did not affect the correlations or t-tests.

Table 1 — Sample characteristics. Values shown as mean (SD) or n (%).

Variables	Values
Age, yr, *mean (SD)*	61 (8.2)
Sex, n (%) *male*	45 (83.3)
BMI, *kg/m² mean (SD)*	27.4 (3.6)
LVEF, *mean (SD)*	58 (9.7)
Ex-smokers, n (%)	32 (68.1)
Myocardial infarction, STEMI, n (%)	36 (75)
Physically active, n (%)	15 (29.4)
AACVPR risk classification, n (%)	
Low	28 (57.1)
Moderate	18 (36.7)
High	3 (5.6)
VSAQ, *mean (SD)*	6.2 (2)
Beta-blocker use, n (%)	50 (92.6)
Systemic Arterial Hypertension, n (%)	37 (69.8)
Dyslipidemia, n (%)	28 (56)
Diabetes mellitus, n (%)	16 (29.6)
Graded exercise test	
Peak MET, *mean (SD)*	7.7 (2.7)
HR peak, bpm, *mean (SD)*	122.3 (19.2)
Maximal double product, mm Hg x bpm, *mean (SD)*	19,885.5 (4,592.7)

AACVPR= American Association of Cardiovascular and Pulmonary Rehabilitation; BMI= body-mass index; HR peak= peak heart rate reached during graded exercise test expressed as a percentage of age predicted heart rate; LVEF= left ventricle ejection fraction; MET= metabolic equivalent; SD= standard deviation; STEMI= ST segment elevation myocardial infarction; VSAQ= *Veterans Specific Activity Questionnaire*.

DISCUSSION

This study reveals that fewer participants maintained their exercise intensities within the prescribed HRTZ with the progressive protocol. Nevertheless, improvements in functional capacity were still observed, likely owing to participants not training too far below the lower HRTZ threshold.

In our study, 48.1% of the participants did not have their functional capacity improved above the 70 m minimal clinically relevant difference[21]. We found a weak correlation between mean exercise HR, Borg-RPE, and changes in functional capacity. This may be related to how often participants trained below the minimum HRTZ threshold, which did not exceed 8.6%. Khushhal et al. found that participants trained on average 3% below the lower HR threshold of their prescribed intensity[8]. Although they exercised on average 6.5% below the HRTZ in our study, we believe that this was not sufficient to impair improvements in functional capacity. Other factors could have influenced it, such as focusing on maintaining above the minimum HR threshold rather than the midpoint or upper HR limit within the HRTZ. Another reason could be the participants not meeting their weekly exercise unsupervised goals. In addition, 92.6% of our participants were prescribed ß-blockers, which attenuate the HR response to exercise, consequently narrowing the HRR and potentially impairing the ability to remain within higher HRTZ. Thus, tracking exercise intensity using subjective measures such as Borg-RPE can help track exercise intensity in such participants. However, this study did not find a correlation between functional capacity and Borg-RPE.

Retrospective studies have known limitations related to their design, such as not having a control group and restrictions on their generalizability and external validity. However, our study contributes to the literature and clinical practice because it focuses on an important functional capacity measure (i.e., distance walked).

Additionally, the ISWT is a valid instrument that correlates with increases in maximal oxygen uptake. Our study shows that although many participants do not exercise within the HRTZ, particularly as the intensity progresses, there are still improvements in functional performance measured by the ISWT. This, nevertheless, may reflect our limited ability to quantify the training stimulus.

This study was performed in a public university hospital setting, in which cardiac rehabilitation therapists are often responsible for assisting 2-4 patients simultaneously, and participants cannot always afford heart rate monitors. Moreover, our participants were mainly older adults who reportedly had not previously exercised using a treadmill before enrolling in this CVR

Table 2 — Outcomes by adherence to heart rate training zones: below, intermediate, or above HRTZ.

	HRTZ			
	Below (n = 13)	Intermediate (n = 15)	Above (n = 26)	p-value
Pre ISWT, meters	355.4 (145.8)	384 (124.3)	386.1 (123.4)	0.77
Post ISWT, meters	423.8 (167.3)	405.3 (122.5)	465.4 (131.5)	0.38
Delta ISWT, meters	68.5 (89.4)	21.3 (86.6)	79.2 (98.9)	0.16
HR rest, bpm	68 (6)	71 (8)	65 (7)	0.05
HR at peak exercise, bpm	96 (12)	99 (13)	101 (16)	0.48

HRTZ= heart rate training zone, Delta ISWT= post-pre distance walked in the incremental shuttle walk test (ISWT); HR= heart rate in beats per minute. Significance level was set at $p < 0.05$.

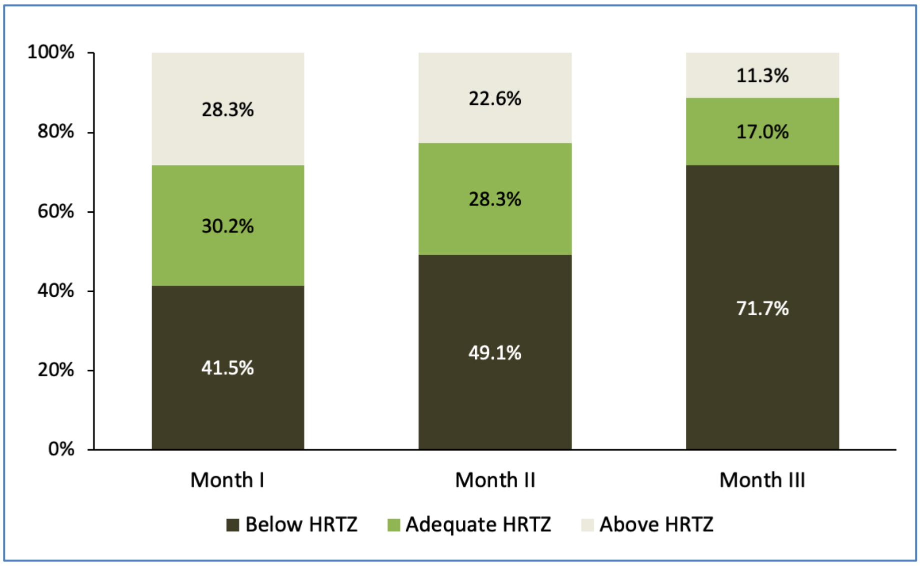

Figure 2 — Heart rate training zone adherence. HRTZ: heart rate training zone.

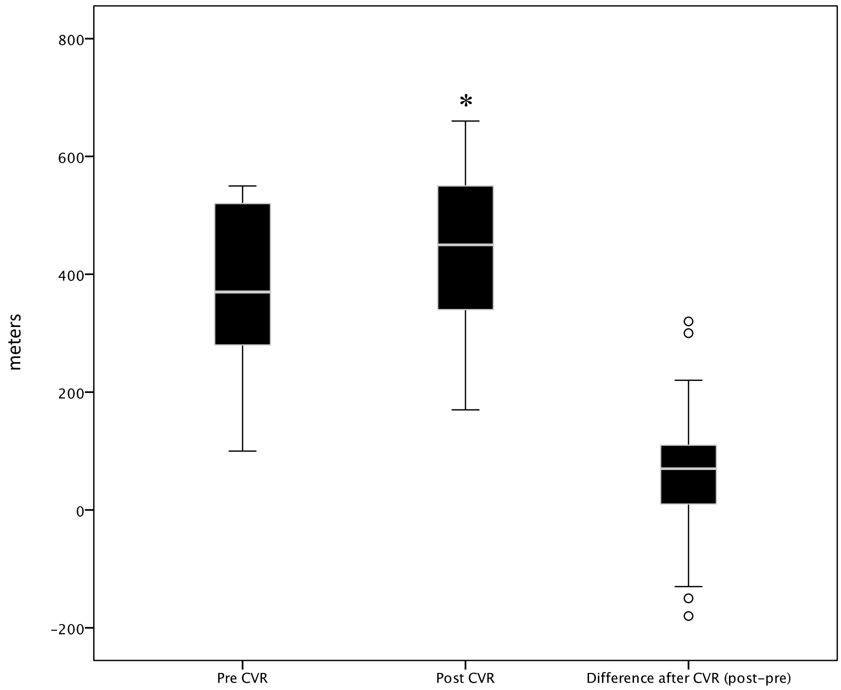

Figure 3 — Boxplot with mean distance walked in the Incremental Shuttle Walk Test (functional capacity) pre, post and in response to the cardiovascular rehabilitation program. CVR= cardiovascular rehabilitation. *Statistically significant change ($p < 0.05$). Open circles (°) represent outliers.

program. Inexperience may have induced fear of going further, especially after a cardiac event, and the general challenge of having one-on-one guidance from a therapist throughout the entire session.

One participant showed a decrease of 180 m in the distance walked in the ISWT, had a depressed chronotropic response (chronotropic index: 0.56; reference > 0.62) in their admission GXT, a drop in systolic blood pressure in 16.6% of their CVR sessions, and trained below HRTZ during 75% of the program. Another outlier decreased the distance walked in the ISWT by 150 m after the CVR program. In their screening test, this patient had an EFLV of 42% and hypokinesia of the left ventricle. During this participant's program, they were suspended from treadmill training because of dyspnea and dizziness and trained under their HRTZ in 35% of their sessions.

The other two outliers were individuals who had improved by 300 and 320 m. The first trained above their HRTZ in 41.6% of the sessions and stated they consistently performed unsupervised exercise training, and the second trained above their HRTZ in 62.5% and within HRTZ in 37.5% of the sessions and never exercised below HRTZ. The current literature agrees that higher intensities achieved during CVR can optimize the benefits of exercise. Although the limited data from two participants precludes the ability to draw definitive conclusions, it nevertheless suggests the importance of adhering to the overload principle: greater intensities generally yield greater outcomes.

There are discrepancies in exercise prescription approaches and the volume of training across cardiovascular rehabilitation programs, making it complex to analyze overall improvements. Other studies have found a correlation between exercise intensity and cardiorespiratory improvements such as VO_{2peak} and functional capacity[22-23]. Our study agrees with the recommendations reviewed by Mitchell et al.[22] in that we investigated adherence to exercise prescription as one of the major factors influencing functional improvements.

Thus, our recommendation for future studies is to include an exercise diary to monitor training volume and define training profiles to measure its impacts on functional capacity. We believe this is an accurate and realistic clinical study in a public hospital in a low- to middle-income country and can be generalized to other similar settings. Our study shows that even in scenarios with few resources and financial support, exercise in CVR programs is essential to improve functional capacity in patients with post-myocardial infarction. Future studies should aim for a larger sample size and randomized trials.

Our main take-home messages are that any exercise is better than none in outpatients referred to CVR programs. Also, exercise intensity is not the sole factor responsible for increases in functional capacity. Encouraging participants of CVR programs to engage in unsupervised physical activity is also crucial. Further investigations should be conducted to identify the relationships between training volume in rehabilitation programs that also use progressive intensities.

CONCLUSION

Despite improvements in functional capacity in most participants, 48.1% did not show significant achievements in this progressive exercise program, which can partly, but surely not solely, be attributed to participants not exercising within their prescribed HRTZ. This points to the importance of keeping within HRTZ and reinforcing the participant of CVR programs their role in monitoring HR during exercise, especially where a one-on-one approach is not possible, and their role in engaging in unsupervised exercise to optimize the benefits of cardiac rehabilitation.

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Writing of the manuscript: PEOG, TSN, BRP, DAGP, RRB, ST
Critical revision of the text: PEOG, TSN, BRP, DAGP, RRB, ST
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