

Assessment of a cardiac rehabilitation program based on the Borg RPE Scale and six-minute walk test

ABSTRACT

Aims: The ability of cardiac rehabilitation interventions to reduce mortality in those with cardiovascular disease is well established. Despite its widespread use in the clinical setting, the Borg Rating of Perceived Exertion (RPE) scale is yet to be validated for its ability to produce equivalent physiological health outcomes to those achieved in programs where exercise intensity was prescribed on the basis of a maximal or submaximal exercise test.

Study design: Closed Cohort Study.

Place and Duration of Study: Department of Physiotherapy, Albury Base Hospital and School of Community Health, between November 2008 and November 2009.

Methodology: Fifteen participants were assessed prior to and following completion of a cardiac rehabilitation program where exercise was prescribed according to the Borg RPE scale. Pre and post Six-Minute Walk Test scores were obtained to determine the impact of the cardiac rehabilitation program.

Results: Fifteen cardiac rehabilitation participants completed all requirements of the study after an initial enrolment of 22 patients. Wilcoxon signed-ranks test showed statistically significant improvements in 6MWT scores following participation in the cardiac rehabilitation program ($p = .033$) from a median value of 412 metres to 475 metres.

Conclusion: The findings of this study indicate that cardiac rehabilitation programs, where exercise prescription is based on the Borg RPE scale, are capable of improving exercise capacity measured as 6MWT and thus reducing possible risk of future adverse cardiac events.

Keywords: Cardiac rehabilitation, Borg rating of perceived exertion, six minute walk test, cardiovascular disease

1. INTRODUCTION

Cardiac rehabilitation forms an integral component of the complex health provision recommended for those with cardiovascular disease (CVD). Structured exercise programs within cardiac rehabilitation lead to both peripheral and cardiopulmonary adaptations whilst directly reducing mortality (1). However, this evidence is based on studies that have prescribed and monitored exercise intensity on the basis of an initial maximal or submaximal (graded) exercise test. These findings are less relevant to a clinical setting that is becoming increasingly reliant on less objective means of exercise prescription such as the Borg rating of Perceived Exertion (RPE) scale (2). Despite its widespread use in the clinical setting, there is a lack of research documenting cardiac health outcomes following participation in cardiac rehabilitation programs where exercise is prescribed according to the Borg RPE Scale.

The Borg RPE method consists of a vertical scale from 6-20 with corresponding verbal expressions of progressively increasing sensation intensity (3). Current cardiac rehabilitation guidelines recommend a "low to moderate exercise intensity" for this population which corresponds with a Borg RPE of 10-13/20 (4, 5). Based on the close correlations shown between the Borg RPE scale and heart rate and heart rate variability (6-9), VO_2max (6, 10), and lactate threshold (11, 12), the Borg RPE scale has been readily adopted in clinical

31 practice under the assumption that subsequent health adaptations will also correlate in a
32 rehabilitation setting(13, 14).The Borg RPE scale is a more viable option in cardiac
33 rehabilitation as it does not require expensive equipment, lengthy testing procedures, and is
34 unaffected by medications that commonly alter heart-rate responses to exercise(2, 15).The
35 current emphasis placed on evidence-based practice necessitates that the Borg RPE scale
36 be reviewed for its ability to be used to assess an appropriate level of exercise, which
37 promotes a positive physiological health outcome.
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39 The Six-Minute Walk Test (6MWT) is frequently used as an outcome measure in Australian
40 cardiac rehabilitation programsand its validity in providing an objective measure of functional
41 walking capacity is widely documented in this population(16-18). No studies have
42 documented whether improvements in functional walking capacity are likely following
43 participation in cardiac rehabilitation programs based on the Borg RPE scale.
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45 The current study, aimed to investigate whetherthe Borg RPE scale has the ability to
46 produce positive health outcomes assessed with the 6MWT.
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48 2. MATERIAL AND METHODS

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50 A one-group pretest-posttest research design was used to examine changes in exercise
51 capacity of participants following a six-week cardiac rehabilitation program. Baseline tests
52 were conducted prior to commencing rehabilitation using standardised protocols and these
53 tests were repeated upon completion of the program. The inclusion criteria for the study
54 were in accordance with the inclusion criteria for the cardiac rehabilitation program at the
55 Albury Base Hospital (ABH) NSW, Australia. This program receives referrals from inpatient
56 settings following acute events, revascularisation procedures, or direct referrals from general
57 practitioners and specialists. We did not exclude any participant on the basis of age, gender
58 or cardiac condition with the aim of increasing the generalizability and external validity of
59 findings. However any at risk patients of exercise induced ischemia were not included in the
60 current study as per guidelines and recommendations by the physician.Participants were
61 excluded if they were unable to complete the cardiac rehabilitation program within the six-
62 week period or could not participate in the designated exercise program. A total of twenty-
63 two participants agreed to take part in the study, fifteen of which were used for the final
64 analysis. The project was conducted in accordance with ethics guidelines and approval from
65 the Charles Sturt Ethics in Human Research Committee and Albury-Wodonga Joint
66 Hospitals Ethics Committee. All participants were provided with an information sheet and
67 consent form.
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69 A total of twenty-two people agreed to participate in the study. Seven people were unable to
70 complete the cardiac rehabilitation program within the six-week period due to illness and
71 personal circumstances. Fifteen cardiac rehabilitation participants completed all
72 requirements of the study. Demographic data for these participants are outlined in Table 1.
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Table 1. Demographic data for participants

	Number of Participants (N)
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Subjects (N)	15
Age (years) (mean ± SD*)	67 ± 9
Male	10
Female	5
Diabetic	1
Smoker	0
Reason For Referral	
Post AMI	7
Post AMI + Stent	3
Post AMI + CABG	1
CAD + Stent	1
CAD + CABG	1
Post NSTEMI + Stent	2
Elapsed Period of Time Between Cardiac Event & Commencement of Rehabilitation	
Less Than 2 Weeks	4
Between 2 and 4 Weeks	6
Between 4 and 8 Weeks	2
Greater Than 8 Weeks	3

*SD, standard deviation; AMI, acute myocardial infarction; NSTEMI, non ST elevation myocardial infarction; CAD, coronary artery disease; CABG, coronary artery bypass graft

Participants attended rehabilitation once a week for six weeks. This program was divided into one hour of exercise and one hour of education. The exercise component of rehabilitation was conducted according to ABH guidelines, which have been devised in accordance with those provided by the National Heart Foundation of Australia (19). Each participant was given an individualised exercise program consisting of aerobic (cycle ergometry, treadmill walking and rowing) and circuit training that was devised by a physiotherapist to ensure participants could exercise continually throughout the session at the prescribed level of intensity. Circuit training in this program is most appropriately classified as aerobic in nature (low resistance, high repetition). In accordance with recommendations of the National Heart Foundation, all participants were encouraged to maintain a "low to moderate" intensity (between 10-13/20 on the Borg RPE scale) throughout exercise sessions. Adjustments were made each week to the duration, speed or resistance of aerobic exercise and to the load or number of repetitions performed during circuit training. Participants were also advised to complete a home walking program, as recommended by the National Heart Foundation to achieve 30 minutes of moderate intensity physical activity on most, or all days of the week.

The majority of patients were on polypharmacy including antihypertensives, statins and antiarrhythmic medication. The type of medication used by patients in this study is shown in Table 2.

109 **Table 2. Medication use by patients**

Medication Type	Number of Patients
Anticoagulants/NSAID	4/11
Antihypertensives	
Beta-1 antagonists	7
Angiotensin Converting Enzyme Inhibitors	5
Alpha-2 antagonists	7
Anti-asthmatic	
Beta-2 agonist	3
Anti-lipidemic	
Statins	9
Antiarrhythmic	2
Antiangina	3
Diuretics	3

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111
112 The primary outcome measure used in the cardiac rehabilitation program at the Albury Base
113 Hospital is the Six-Minute Walk Test (6MWT). This test consists of walking up and down a
114 30m indoor track as many times as possible within a 6-minute period. In accordance with the
115 American Thoracic Society guidelines (2002) this test was conducted twice prior to
116 commencing cardiac rehabilitation, with the best of the two tests recorded to allow for a
117 learning effect(20). Other information obtained from cardiac rehabilitation included
118 medications, blood pressure, smoking status, and diabetes status. A cardiac history
119 questionnaire was given to all participants to ascertain any other factors that may impact on
120 their Borg assessment or 6MWT as well as a post-rehabilitation exercise questionnaire to
121 ascertain how active participants had been each week. Participants were also asked to
122 complete a diary of additional exercise and home walking conducted outside of cardiac
123 rehabilitation.

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125 Statistical analysis was performed using Microsoft EXCEL (Copyright Microsoft Inc) and
126 SPSS Version 20.0 (Copyright IBM Inc). Descriptive statistics were initially computed so that
127 data could be compared to previous studies. A Wilcoxon's test was used to compare 6MWT
128 parameters pre and post cardiac rehabilitation. Differences were considered significant when
129 $p < 0.05$.

130 131 3. RESULTS AND DISCUSSION

132 133 3.1 Patient characteristics

134 An overview of the cardiac rehabilitation exercise program is outlined in Table 3. Details are
135 provided for both supervised exercise and participation in the prescribed home walking
136 program. The supervised sessions were tailored to ensure each participant could maintain
137 the prescribed level of intensity (Borg RPE between 10-13/20) for the duration of the 1-hour
138 program. Time spent on each modality varied between participants to allow for maintenance
139 of this intensity.

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141 **Table 3. Overview of Participation in Cardiac Rehabilitation Exercise Program**

Number of Participants

<i>Attendance</i>		
	All 6 sessions	15
	< 6 sessions	0
<i>Modalities used</i>		
	Treadmill Walking	13
	Exercise Bike	15
	Upper body free weights	14
	Lower body cuff weights	4
	Squats	9
	Step ups	9
	Rowing	4
	Sit to stand	5
<i>Frequency of Home Walking</i>		
	6-7 days/week	5
	3-5 days/week	4
	1-3 days/week	0
	Non walkers	6
<i>Average Duration of Home Walking</i>		
	> 30 minutes/day	1
	30 minutes/day	7
	< 30 minutes/day	1
	Non walkers	6

Wilcoxon signed-ranks test showed statistically significant improvements in 6MWT scores following participation in the cardiac rehabilitation program ($p = .033$). Data provided in Table 4 pertain to the fifteen participants who completed both pre and post 6MWT. These participants improved for the 6MWT from a median value of 412 metres to 475 metres.

Table 4. Effect of Cardiac Rehabilitation on 6MWT

	6MWT Distance		z value	p value
Subjects	Before Training (m)	6MWT Distance After Training (m)		
Minimum	265	140		
Maximum	490	560		
Median	412	475	-2.127 (b)	.033

(b) = Based on negative ranks

157 6MWT data were also compared to the only known study that has examined the use of the
 158 6MWT in a cardiac rehabilitation population (21). Table 5 highlights that the population of the
 159 current study began at a higher functional capacity and saw a less significant change
 160 between pre and post-testing. Both studies saw an improvement regardless of age or
 161 gender.

162
 163 **Table 5. Comparison of 6MWT data with Fiorina results**

	Initial Distance Walked		Final Distance Walked		%Improvement	
	Our Study*	Fiorina et al.	Our Study	Fiorina et al.	Our Study	Fiorina et al.
Subjects						
Men	433 ± 44	300 ± 86	456 ± 116	429 ± 104	5.3	30
Women	414 ± 41	235 ± 82	460 ± 29	366 ± 103	11.1	35
Age < 70 years	433 ± 44	304 ± 88	484 ± 35	444 ± 102	11.3	31
Age > 70 years	392 ± 68	246 ± 81	425 ± 132	359 ± 94	8.4	31

164 * 6MWT – distance walked is provided in meters.

165 166 **3.2 The role of 6MWT and Borg RPE scale in cardiac rehabilitation**

167 The purpose of this study was to determine the capacity of exercise prescription using the
 168 Borg RPE scale to induce physiological adaptations within the cardiovascular system in a
 169 cardiac rehabilitation population. Cardiac rehabilitation exercise programs based on maximal
 170 or submaximal exercise tests are widely documented to result in a number of physiological
 171 health benefits as well as directly decreasing mortality rates (1, 22). However, the extent to
 172 which these findings apply to a large percentage of Australian cardiac rehabilitation
 173 programs is limited by a lack of studies examining the effect of exercise prescription based
 174 on the Borg RPE scale on equivalent health outcomes. This study examined functional
 175 walking capacity as judged by the 6MWT as a measure of cardiac rehabilitation
 176 effectiveness.

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 178 The specific level of exercise intensity prescribed in the current study must also be examined
 179 as an issue of its own, separate from the methods used to prescribe it. In accordance with
 180 national cardiac rehabilitation guidelines, a low to moderate level of intensity was prescribed
 181 for all participants. Low to moderate intensity correlates with a Borg RPE of 10-13/20 and a
 182 HRmax of 35-69% (5). Although no minimum values have been established for exercise a
 183 recent overview of cardiac rehabilitation research found that 45% VO₂R (oxygen uptake
 184 reserve) is the minimum intensity required to improve aerobic capacity in this population
 185 (23). This equates to approximately 60% of HRmax(24), which equates to the upper limit
 186 within our study. Participants with a Borg RPE of 10-13/20 in the current study were training
 187 at the lower level of the prescribed guidelines and therefore working significantly under the
 188 threshold needed to induce an aerobic training effect. Based on the current research
 189 though, it seems likely that the training intensities employed may have been adequate for a
 190 positive training effect and thus indicate a possible improvement in heart function. However a
 191 larger sample size needs to be employed to verify these results.

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Exercise frequency in the current study pertains to both the number of supervised exercise sessions and participation in the prescribed home walking program. Our findings indicate that a larger percentage of those who participated in home walking saw an improvement in the 6MWT and would suggest that an increased exercise frequency is associated with an increased exercise capacity, which may decrease the risk for future adverse cardiac events. These trends support a recent meta-analysis of cardiac rehabilitation training modalities where greater frequency of sessions had a greater training effect in this population(22).

Although all forms of additional aerobic and resistance training were documented, we did not attempt to quantify incidental forms of exercise or lifestyle changes that may have explained these findings. It is often argued that these lifestyle changes and the development of a knowledge base has the greatest impact on mortality rates in cardiac rehabilitation (25). The training effect measured by 6MWT seen in the current study regardless of exercise frequency is an interesting finding and one that has potential implications for the clinical setting, which will be discussed further.

This study is the first to demonstrate improvements in 6MWT scores following participation in a cardiac rehabilitation exercise program based on the Borg RPE scale ($p = .033$). Results of the current investigation were compared with the only other known study examining the impact of cardiac rehabilitation on the 6MWT (see Table 4)(21). Although the percentage of improvement seen by Fiorina et al. was greater than that seen in the current study, both investigations saw an improvement in 6MWT scores regardless of age or gender. Inspection of Table 4 reveals that the participants in the current study began at a higher baseline level of functional capacity and therefore may explain a less-significant improvement following completion of the program. In addition the study population reported by Fiorina was larger compared to the present study, which may also have influenced the significance level of the results. Drawing any real comparisons between the two studies is difficult as the cardiac rehabilitation protocols between these groups differ greatly. The program examined by Fiorina et al. was conducted twice daily for a period of 15 ± 3 days with exercise intensity prescribed and monitored on the basis of a symptom-limited exercise test. Exact exercise intensities were not documented.

This study is the first to provide insight into the impact of cardiac rehabilitation, based on the Borg RPE scale, and 6MWT. Findings from this study warrant investigation on a larger scale and further research in this field could spur a re-evaluation of national cardiac rehabilitation guidelines. Results suggest that cardiac rehabilitation as performed in the current study, is able to improve participants' exercise capacity based on the 6MWT and is advantageous in comparison to VO_2 max testing, once considered the gold standard (2), because it measures underlying cardiac health in a manner that produces no discomfort or risk to the participant.

Finally, issues such as non-compliance with home-walking programs and waiting times between cardiac event and commencing rehabilitation are not unique to the confines of this study. They are reflective of the kinds of issues that commonly arise in these programs and the findings of this study suggest that the results previously demonstrated in the highly controlled and idyllic settings of controlled trials may not correlate with the outcomes that can be expected in a clinical setting. Current practice in major cardiac rehabilitation clinics base exercise prescription on graded exercise tests and measures of VO_2 max and ECG characteristics. This is not followed in many smaller cardiac rehabilitation clinics, where the expensive equipment is not available and has been replaced by using the Borg RPE scale. However the Borg RPE scale has not been validated in a cardiac rehabilitation setting and shown to lead to functional improvement. The current study has demonstrated that use of the Borg RPE scale is a viable substitute for exercise prescription and when applied led to improvements in functional capacity following a six weeks cardiac rehabilitation program.

243 The results of this study are pertinent to current practice as they demonstrate the impact of
244 cardiac rehabilitation programs currently in clinical use (once-weekly supervised exercise
245 sessions, based on the Borg RPE scale, for 6-8 weeks) on significant health outcomes.

246

247 **4. CONCLUSION**

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249 This study was the first to examine the ability of cardiac rehabilitation based on the Borg
250 RPE scale to have a positive impact on post-MI patients using the 6MWT. Results suggest
251 that programs performed in this manner are capable of having a favourable impact on
252 exercise capacity measured as 6MWT and therefore possible reduced risk of future adverse
253 cardiac events. Our analyses indicated that cardiac rehabilitation providers can be confident
254 that a heterogeneous mix of cardiac conditions, surgeries and genders will not significantly
255 alter participant outcomes.

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258 **COMPETING INTERESTS**

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260 There are no financial and personal relationships with other people or organizations that
261 inappropriately influenced (bias) this work.

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264 **CONSENT**

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266 All authors declare that 'written informed consent was obtained from the patient (or other
267 approved parties) for publication of this study. A copy of the written consent is available for
268 review by the Editorial office/Chief Editor/Editorial Board members of this journal.

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271 **ETHICAL APPROVAL (WHEREEVER APPLICABLE)**

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273 All authors hereby declare that all experiments have been examined and approved by the
274 appropriate ethics committee and have therefore been performed in accordance with the
275 ethical standards laid down in the 1964 Declaration of Helsinki."

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