



Assessment of a Cardiac Rehabilitation Program Based on the Borg RPE Scale by Six-minute Walk Test: A Pilot Study

Herbert F. Jelinek^{1,2*}, Thomas Collins³, Megan Smith¹ and Hosen Kiat²

¹School of Community Health, Charles Sturt University, Albury, Australia.

²Australian School of Advanced Medicine, Macquarie University, Sydney, Australia.

³Department of Physiotherapy, Austin Repatriation Hospital, Melbourne, Australia.

Authors' contributions

This work was carried out in collaboration between all authors. Authors HFJ and MS designed the study, and wrote the protocol. Author TC wrote the first draft of the manuscript. Author TC managed the literature search and experimental process. Analyses of the study were carried out by all authors. All authors read and approved the final manuscript.

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ABSTRACT

Aims: The ability of cardiac rehabilitation 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 lead to improvements in functional capacity.

Study Design: A closed cohort pilot 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. Exercise was prescribed according to the Borg RPE scale. Pre and post Six-Minute Walk Test (6MWT) 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: In this pilot study, cardiac rehabilitation programs based on the Borg RPE scale may improve functional capacity measured by 6MWT during a 6-week period.

*Corresponding author: E-mail: hjelinek@csu.edu.au;

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 sub maximal (graded) exercise test. These findings are less relevant to a clinical setting that bases exercise prescription on the Borg rating of Perceived Exertion (RPE) scale [2]. Despite the Borg RPE scale being in widespread use in the clinical setting, there is a lack of research documenting functional improvements in post cardiac intervention patients 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_2 max [6,10], and lactate threshold [11,12], the Borg RPE scale has been readily adopted in clinical practice under the assumption that subsequent health adaptations will also correlate in a rehabilitation setting [13,14]. In rural cardiac rehabilitation programs, the Borg RPE scale is also a more viable option as it does not require expensive equipment, lengthy testing procedures, and is unaffected by medications that commonly alter heart-rate responses to exercise [2,15]. However the Borg RPE scale needs to be reviewed for its ability to be used to assess an appropriate level of exercise, which promotes a positive physiological health outcome.

Improvements in functional capacity are traditionally determined by measuring post-rehabilitation VO_2 max following sub-maximal exercise. In Australian cardiac rehabilitation programs, the Six-Minute Walk Test (6MWT) is frequently used as an outcome measure in place of VO_2 max and its validity in providing an objective measure of functional walking capacity is widely documented [16-18]. However no studies have documented whether improvements in functional capacity are likely following participation in cardiac rehabilitation programs based on the Borg RPE scale.

The current study, aimed at investigating whether the Borg RPE scale has the ability to improve functional capacity assessed with the 6MWT.

2. MATERIALS AND METHODS

A one-group pretest-posttest research design was used to examine changes in exercise capacity of participants following a six-week cardiac rehabilitation program. Baseline tests were conducted prior to commencing rehabilitation using standardised protocols and these tests were repeated upon completion of the program. The inclusion criteria for the study were in accordance with the inclusion criteria for the cardiac rehabilitation program at the Albury Base Hospital (ABH) NSW, Australia. This program receives referrals from inpatient

settings following acute coronary events, cardiac surgeries including coronary revascularization, or direct referrals from general practitioners and specialists of patients with coronary risk factors. We did not exclude any participant on the basis of age, gender or cardiac condition but any at risk patients of exercise-induced ischemia were not included in the current study as per guidelines and recommendations by the physician. Participants were excluded if they were unable to complete the cardiac rehabilitation program within the six-week period or could not participate in the designated exercise program. A total of twenty-two participants consented to take part in the study, fifteen completed the program. Seven people were unable to complete the cardiac rehabilitation program within the six-week period due to illness and personal circumstances. Demographic data for these participants are outlined in Table 1. The project was conducted in accordance with ethics guidelines and approval from the Charles Sturt Ethics in Human Research Committee and Albury-Wodonga Joint Hospitals Ethics Committee. All participants were provided with an information sheet and signed the consent form prior to commencing the study.

Table 1. Demographic data for participants

| | Number of participants (N) |
|---|-----------------------------------|
| 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

Other information obtained from cardiac rehabilitation included medications, blood pressure, smoking status, and diabetes status. A cardiac history questionnaire was given to all participants to ascertain any other factors that may impact on their Borg assessment or 6MWT as well as a post-rehabilitation exercise questionnaire to ascertain how active participants had been each week. Participants were also asked to complete a diary of additional exercise and home walking conducted outside of cardiac rehabilitation. The majority of patients were on poly pharmacy including antihypertensive medication, statins and anti arrhythmic medication. The type of medication used by patients in this study is shown in Table 2.

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 |

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

2.1 Program Participation

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 was conducted according to the National Heart Foundation of Australia guidelines [19]. Each participant was given an individualised exercise program consisting of aerobic (cycle ergometry, treadmill walking and rowing) circuit training that was devised to ensure participants could exercise continually throughout the session at the prescribed level of intensity. Circuit training in this program consisted of low resistance, high repetition and maintaining a “low to moderate” intensity (between 10-13/20 on the Borg RPE scale) throughout the exercise sessions [19]. 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.

2.2 Cardiac Rehabilitation Outcome Measure

The primary outcome measure used in the cardiac rehabilitation program in rural areas including the Albury Base Hospital is the Six-Minute Walk Test (6MWT). This test consists of walking up and down a 30m indoor track as many times as possible within a 6-minute period. In accordance with the American Thoracic Society guidelines (2002) this test was conducted twice prior to commencing cardiac rehabilitation, with the best of the two tests recorded to allow for a learning effect [20].

3. RESULTS AND DISCUSSION

3.1 Patient Characteristics

An overview of the cardiac rehabilitation exercise program for the 15 patients included in the study is outlined in Table 3. Details are provided for both supervised exercise and participation in the prescribed home walking program. The supervised sessions were tailored to ensure each participant could maintain the prescribed level of intensity (Borg RPE between 10-13/20) for the duration of the 1-hour program. Time spent on each modality varied between participants to allow for maintenance of this intensity.

Table 3. Overview of participation in cardiac rehabilitation exercise program

| | | Number of participants |
|----------------------------------|-------------------------|------------------------|
| Attendance | All 6 sessions | 15 |
| | <6 sessions | 0 |
| Modalities used | 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 |
| Frequency of home walking | 6-7 days/week | 5 |
| | 3-5 days/week | 4 |
| | 1-3 days/week | 0 |
| | Non walkers | 6 |
| Average duration of home walking | >30 minutes/day | 1 |
| | 30 minutes/day | 7 |
| | <30 minutes/day | 1 |
| | Non walkers | 6 |

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. Improvement was seen regardless of age and gender. The Wilcoxon signed-ranks test showed statistically significant improvements in 6MWT scores following participation in the cardiac rehabilitation program ($p=.033$).

3.2 The Role of 6MWT and Borg RPE Scale in Cardiac Rehabilitation

The purpose of this study was to determine the capacity of exercise prescription using the Borg RPE scale to improve functional capacity in a cardiac rehabilitation population [21]. Cardiac rehabilitation exercise programs based on maximal or sub maximal exercise tests are widely documented to result in a number of physiological health benefits as well as directly decreasing mortality rates [1,22]. However, the extent to which these findings apply

to a large percentage of Australian cardiac rehabilitation programs is not known as there have been no previous studies examining the effect of exercise prescription based on the Borg RPE scale on 6MWT. This study examined functional capacity as judged by the 6MWT as a measure of cardiac rehabilitation effectiveness.

Table 4. Effect of cardiac rehabilitation on 6MWT

| Subjects | 6MWT distance before training (m) | 6MWT distance after training (m) | z value | P value |
|-----------------|--|---|----------------|----------------|
| Minimum | 265 | 140 | | |
| Maximum | 490 | 560 | | |
| Median | 412 | 475 | -2.127 (b) | .033 |

(b) = Based on negative ranks

In accordance with national cardiac rehabilitation guidelines, a low to moderate level of intensity was prescribed for all participants. Low to moderate intensity correlates with a Borg RPE of 10-13/20 and a HRmax of 35-69% [5]. Although no minimum values have been established for exercise a recent overview of cardiac rehabilitation research found that 45% VO₂R (oxygen uptake reserve) is the minimum intensity required to improve aerobic capacity in this population [23]. This equates to approximately 60% of HRmax [24]. Of clinical importance is that the recommended HRmax equates to the upper limit within our study. In addition although the participants with a Borg RPE of 10-13/20 were training at the lower level of the prescribed guidelines and therefore working significantly under the threshold needed to induce an aerobic training effect, the training intensities employed were sufficient for a positive training effect and indicated an improvement in functional capacity.

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 suggests that an increased exercise frequency is associated with an improvement in functional capacity. Improvement in functional capacity due to increased frequency of exercise including home exercise is also linked to education during cardiac rehabilitation programs that emphasize home exercise, which is often neglected by patients [25]. Our findings are supported by a recent meta-analysis of cardiac rehabilitation training modalities where greater frequency of sessions had a greater training effect [22].

Our study is the first to demonstrate improvements in 6MWT scores following participation in a cardiac rehabilitation exercise program based on the Borg RPE scale. Results of the current investigation were compared with the only other known study examining the impact of cardiac rehabilitation on the 6MWT [21]. Although the percentage of improvement seen by Fiorina et al. [21] was greater than that seen in the current study, both investigations saw an improvement in 6MWT scores regardless of age or gender. The larger increase in post-rehabilitation 6MWT distance reported by Fiorina et al. [21] may be due to participants in the current study having a higher baseline distance. However, an increase of 54 meters in the distance walked post cardiac rehabilitation and recommended by the American Thoracic Society was reached by the current participants [20]. Drawing any real comparisons between the current study and that of Fiorina et al. [21] is difficult as the cardiac rehabilitation protocols between these two studies differ greatly. The program examined by Fiorina et al. [21] 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.

Current practice in major cardiac rehabilitation clinics base exercise prescription on graded exercise tests and measures of VO₂max 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. The results of this study are pertinent to clinical practice as they demonstrate the impact of cardiac rehabilitation programs currently in clinical use (once-weekly supervised exercise sessions, based on the Borg RPE scale, for 6-8 weeks) on significant improvements in functional capacity.

4. CONCLUSION

In this pilot study, the 6-week cardiac rehabilitation program, based on the Borg RPE scale improved functional capacity measured by 6MWT. A further large sample-sized study is worthwhile to be conducted in order to confirm our findings.

CONSENT

All authors declare that 'written informed consent was obtained from the patient (or other approved parties) for publication of this study.

ETHICAL APPROVAL

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

COMPETING INTEREST

Authors have declared that no competing interests exist.

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