

THE RELATIONSHIP BETWEEN HEART RATE AND RATE OF
PERCEIVED EXERTION AMONG PHASE II CARDIAC
REHABILITATION PATIENTS WITH VARIOUS
MODES OF EXERCISE

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ABSTRACT

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The purpose of this study was to determine the relationship between heart rate (HR) and rate of perceived exertion (RPE) among phase II cardiac rehabilitation patients with various modes of exercise. 100 subjects were randomly selected from a phase II cardiac rehabilitation program. HR was measured with telemetry recorded EKG tracings. RPE was determined through subject self report using the Borg Rating of Perceived Exertion Scale. Assessments were made during exercise at 4 different exercise modes for each subject on 4 separate exercise sessions: 2, 3, 23, and 24. Exercise modes included a motor driven treadmill, cycle ergometer, arm ergometer, and rowing machine. HR and RPE were obtained during the final 2 minutes of each exercise mode. Pearson product-moment correlations were used to determine the relationship between HR and RPE. A total of 1,600 paired scores were analyzed. The results showed a significant ($p < .05$) relationship between HR and RPE with the treadmill ($r = .23$) and rowing machine ($r = .21$) in exercise session two. No significant relationship between HR and RPE was observed for the 4 exercise modes in exercise sessions 3, 23, and 24. These findings reveal the RPE scale is not a reliable measure of exercise intensity in phase II cardiac rehabilitation exercisers.

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CHAPTER I

INTRODUCTION

The concept of perceived exertion offers a unique approach to the study of behavior. An individual's perception of exertion during physical work is interesting when studying man at work or leisure time activities, in diagnostic situations or exercise prescription, and in the evaluation of daily exercise intensities (Borg, 1982). According to Borg (1982) perceived exertion is the single best indicator of the degree of physical strain.

The concept of perceived effort in exercise was first introduced by Borg who developed the rating of perceived exertion (RPE) scale (Borg, 1973). The RPE scale is a 15-grade category scale, ranging from 6, representing rest, to 20, representing activities which are very, very hard. Descriptive words are included with every other number and range from very, very easy at 7, to very, very hard at 19. The 15-grade category scale corresponds to an approximate range of heart rates (60-200 bpm) when multiplied by a constant of 10 (± 10 bpm, i.e., with a RPE of 12, heart rate should be approximately 120 bpm). This scale was developed with healthy middle-aged men while performing varying workloads from light to heavy intensity. Correlation coefficients of .83 and .94 between RPE and HR were found in various groups of healthy subjects and patients with circulatory disorders across a variety of exercise modalities and conditions (Bar-Or, Skinner, Buskirk, & Borg, 1972; Borg & Linderholm, 1970; Borg & Noble, 1974; Skinner, Hutsler,

Bergsteinova, & Buskirk, 1973a; Stamford, 1976; Turkulin, Zamlic, & Pegan, 1977).

The majority of RPE data have been based on studies with healthy adults. Patients with coronary insufficiency and/or myocardial infarction have consistently rated higher RPE's for a given heart rate than a group of age-matched controls (Borg & Linderholm, 1970; Turkulin, et al., 1977). With training, RPE normalized but the linear relationship with heart rate was maintained. The initially high RPE values were thought to reflect a lower maximal work capacity or qualitative difference in perception (e.g., pain perception). As training progressed, the relationship between RPE values and HR increased significantly. These results suggest that RPE may be a useful indicator of exercise tolerance in cardiac patients. However, little data are available on the use of RPE in graded exercise testing (GXT) and rehabilitation with cardiac patients soon after open heart surgery. Gutmann, Squires, Pollock, Foster, and Anholm (1981) noted that postcardiac surgery patients perceive exercise similarly at given heart rates in both graded exercise testing (GXT) and early rehabilitation. However, after training and postsurgical recovery, perception shifts to yield the same RPE at higher HR and MET levels. Since RPE appears to maintain a constant relationship to HR in both GXT and early training in rehabilitation, it could be a useful tool for exercise prescription and monitoring in cardiac rehabilitation.

Since RPE is readily used by most cardiac patients and requires no instrumentation, it is applicable in both home and hospital-based rehabilitation. Rate of perceived exertion allows the physician and

patient to effectively monitor and adjust an exercise program by integrating both subjective and objective data (Gutmann et al., 1981).

The researcher of this study investigated the relationships between RPE and HR in recovering phase II postsurgical and nonsurgical cardiac patients with various modes of exercise used in outpatient phase II cardiac rehabilitation. Specifically, the exercise sessions were conducted 2-3 times a week for a period of 8-12 weeks.

Borg's (1973) psychophysical rating scale was used to evaluate the patient's subjective perception of effort during the exercise sessions.

Purpose of the Study

It was the purpose of this study to determine the relationship between HR and RPE among phase II cardiac rehabilitation program participants with various modes of exercise. Specifically, the study investigated RPE response and its relationship to HR to determine if the RPE scale is a reliable measure of exertion with cardiac patients.

Need for the Study

Ratings of perceived exertion may provide important diagnostic information in cardiac rehabilitation patients. Most clinical studies have demonstrated that the RPE category scale is a reliable measure of exertion with healthy adults. However, a number of studies indicate that a combined RPE-HR model is more accurate in the prediction of exercise intensity than the separate use of RPE or HR. Therefore, this study may provide guidelines for cardiac rehabilitation patients using Borg's RPE Scale regarding intensity during exercise.

Null Hypothesis

It was hypothesized that there would be no significant relationship ($p > .05$) between HR and RPE among phase II cardiac rehabilitation participants with various modes of exercise throughout the exercise sessions. Exercise modes included a motor driven treadmill, cycle ergometer, rowing machine, and arm ergometer.

Assumptions of the Study

The researcher made the following assumptions in the study:

1. All monitoring devices were functioning appropriately.
2. The subjects performed to the best of their ability during the exercise sessions.
3. The exercise physiologist discussed the purpose of the exercise program with the patient prior to beginning the rehabilitation program.
4. An exercise physiologist was present throughout the exercise sessions.
5. Subjects understood the RPE scale as explained to them by the exercise physiologist prior to their first exercise session.
6. Subjects responded appropriately and honestly in their expression of the rating of perceived exertion during the exercise session.
7. Subjects differed in their ability to accurately express their perception of the intensity of exercise. Some of the subjects were more aware of their perceptual sensations than other subjects.

D limitations of the Study

The following delimitations occurred in this study:

1. Subjects were Milwaukee County Medical Complex adult cardiac patients entering phase II cardiac rehabilitation at the Milwaukee County Medical Complex, Milwaukee, Wisconsin. The sample consisted of postsurgical and nonsurgical patients entering the outpatient rehabilitation program.
2. The subjects were selected on a random basis.
3. Subjects experiencing post-open heart surgery complications and unable to complete the phase II cardiac rehabilitation program were not included in the study.
4. Subjects who did not utilize all 4 exercise modes in their rehabilitation sessions were not included in the study.

Limitations of the Study

The following limitations were inherent in this study:

1. The amount of work performed on each exercise mode was dependent upon the patient's level of fitness upon entering the program.
2. The researcher had no control over individual factors such as attitude and motivation of the subjects during their exercise sessions.
3. The researcher did not directly control the data collection. The data was collected by three exercise physiologists at the Milwaukee County Medical Complex and placed in the patient's chart for the researcher to tabulate and analyze.

Definition of Terms

The following terms were used in this study:

Cardiac Rehabilitation - a multiphasic program of medical care that is designed to restore the coronary artery diseased patient to a full and productive life (American College of Sports Medicine, (ACSM), 1991).

Cardiac rehabilitation consist of three major phases.

Phase I - an acute in-hospital phase consisting of low level range of motion activities while progressing to supervised ambulatory therapy.

Phase II - late outpatient phase, which usually begins at the time of hospital dismissal and involves close medical supervision for a period of 8-12 weeks. This program is to provide physical rehabilitation for the resumption of everyday lifestyle activities (Squires, Gau, Miller, Allison, & Lavie, 1990).

Phase III - a long term maintenance and conditioning program without supervision.

Coronary Artery Disease - disease of the coronary arteries that supply blood to the heart muscle, causing damage to or malfunction of the heart (American Medical Association Encyclopedia of Medicine, 1989, p. 309).

Exercise Physiologist - individual concerned with the process of exercise as well as its physiological implications (Brooks & Fahey, 1984, p.4).

Heart Rate - the pulse, calculated by counting the number of QRS complexes or contractions of the cardiac ventricles per unit of time. The heart rate can also be determined by auscultation with a stethoscope or by palpation over the heart (Mosby's Medical, Nursing, and Allied Health Dictionary, 1990, p. 549).

Myocardial Infarction (MI) - an occlusion of a coronary artery caused by atherosclerosis or an embolus resulting from a necrotic area in the vasculature myocardium (Mosby's Medical, Nursing, and Allied Health Dictionary, 1990, p. 785).

Pearson Product-Moment Correlation (r) - a number between -1 and +1 that describes the relationship between pairs of quantitative variables (Witte, 1989, p. 119).

Rating of Perceived Exertion (RPE) - a scale which consists of 15 grades from 6-20 and has been shown to have a high correlation with heart rate (Borg, 1962). For middle-aged men the HR at workloads of medium intensity levels should be fairly close to 10 times the RPE values (Borg, 1970) (see Appendix A).

CHAPTER II

REVIEW OF RELATED LITERATURE

Introduction

The present study examined the relationship between HR and RPE among cardiac rehabilitation patients with various modes of exercise. Specifically, the study investigated RPE response and it's relationship to HR to determine if the RPE scale is a reliable measure of exertion with cardiac patients.

The related literature will be presented in the following sections: introduction of cardiac rehabilitation, ratings of perceived exertion, use of RPE scale to determine exercise intensity, validity of Borg's 15-point Rating of Perceived Exertion (RPE) Scale, therapeutic implications, sensory cues and RPE, and summary.

Introduction to Cardiac Rehabilitation

Purposes of Cardiac Rehabilitation

Cardiovascular rehabilitation is the process of development and maintenance of a desirable level of physical, social, and psychologic functioning after a cardiovascular illness (Squires et al., 1990). The ultimate goal of cardiac rehabilitation is to enable patients with cardiac disorders to resume active and productive lives upon return to the home environment for as long as possible. Objectives for accomplishing this goal include restoring the patients to their optimal physiologic and psychosocial status, prevention of reversal of the underlying atherosclerosis process in patients with coronary heart

disease (CHD), reduce the risk of sudden death and reoccurrence of a myocardial infarction, and alleviate angina pectoris (Leon et al., 1990).

Components

Medically supervised exercise conditioning is the essential element of cardiac rehabilitation programs. Other important components in the process of cardiac rehabilitation include assessing patients with coronary artery disease for the risk of future cardiovascular events, patient education, exercise training, nutritional guidance, risk modification, smoking cessation, control of hypertension, and stress management (Leon et al., 1990).

A multidisciplinary healthcare team consisting of cardiologists, exercise physiologists, nurses, dieticians, and physical and occupational therapists all play an important role in carrying out these elements involved in cardiac rehabilitation. The rehabilitation team must be flexible and individualized since every patient's needs vary a great deal.

Benefits

Benefits from cardiac rehabilitation include improved exercise capacity and decreased symptoms of angina, fatigue, and shortness of breath. Data regarding exercise training after a myocardial infarction (MI) showed a 20 to 25% reduction in mortality and major cardiac events (Squires et al., 1990). Exercise training may result in improved functional capacity, an increase in oxygen utilization, improved maximum oxygen uptake ($\dot{V}O_{2\max}$), and improved cardiovascular efficiency (Leon et al., 1990).

Phases

The rehabilitation process for cardiac patients is divided into three phases:

Phase I: the hospital inpatient period, usually 6-14 days in length for patients with acute myocardial infarctions or following coronary artery bypass graft surgery (CABGS). Program components addressed in phase I include low-level exercise, patient and family education, and group and individual counseling.

Phase II: outpatient rehabilitation, generally 8-12 weeks duration. This phase begins at the time of hospital dismissal and usually involves close medical supervision. Objectives of phase II are to instruct patients in proper exercise training and procedures, and to restore them to a desirable exercise capacity appropriate to their clinical status, life-style, and occupation.

Phase III: the supervised portion of the continued maintenance period, usually 4-6 months in duration. This phase consists of efforts to reduce supervision and to promote self regulation of their own exercise program, hopefully for life. Exercise testing and medical evaluation are included every 3-6 months, and then eventually on a yearly basis or as clinically indicated by the patients physician (ACSM, 1991).

Ratings of Perceived Exertion

Ratings of perceived exertion are being increasingly applied to evaluate, monitor, and prescribe the intensity of physical activity during clinical exercise testing, conditioning programs, occupational tasks, and athletic performance (Demmello, Cureton, Boileau, & Singh, 1987; Noble, 1982). The first studies of perceived exertion in physical

work were performed in the 1960's by Borg. A series of experiments examining RPE during exercise led Borg (1962) to propose perceived exertion as a psychologic cue to physiological responses during exercise. Based on perceptual cues, individuals are able to regulate work intensity at a pace compatible with the requirements of the activity. The cues come in the form of both general feelings of fatigue and exertion, and also specific sensations (Borg & Noble, 1974). These specific sensations include joint and muscular pain, shortness of breath, and heart palpitations. Borg and Noble (1974) acknowledged that:

The overall perception of exertion may be regarded as a gestalt or configuration of various sensations and feeling of effort and stress due to physical work. Peripheral sensations from the muscles and joints and central sensations from the cardiovascular system, etc., form together with previous experiences the perception of exertion (p. 150).

Early research in perceived exertion focused on the validation of Borg's (1962) model which linked the perceptual response during exercise evaluation of the effort of physical work with heart rate. Studies by Borg (1973), Ekblom and Goldbarg (1971), and Skinner et al. (1973a) all tested this experiment. These tests used different types of physical work and varied work intensities. A high correlation between RPE and HR was found with all the studies.

Borg and Dahlstrom's first study (cited in Borg, 1962) dealt with psychophysical investigations of subjective force and perceived exertion. A ratio estimation experiment for short-time work on the bicycle ergometer was performed. The results showed the subjective perception of the force applied followed a positively accelerating function, described with the expression: $R = c(S+b)^n$, R is the

subjective force, c is a measure-constant, S is the physical intensity, b is a basic constant, and n is the exponent. The exponent showed a positively acceleration exponent of 1.6, with a high test-retest correlation of .95. The work of Stevens and Mack (cited in Borg, 1973) studied the subjective perception of a handgrip force, obtaining a positive exponent of $n = 1.7$, and Eister (cited in Borg, 1973) found a positive exponent of $n = 1.6$ for isometric leg force. These studies showed a positively accelerated function with about the same exponent, supporting the idea that subjective intensity grows according to a positively accelerated function with the physical work load.

The Borg Scale represents only one of many psychophysical methods. Due to the fact that the psychophysical methods were of very little help in practical work with people, Borg developed methods to be used in clinical diagnosis for exercise prescription. The ratio scaling method yielded only ratios between percepts and no direct levels of interindividual comparison (Borg, 1973). These limitations lead Borg to develop a simple method that could be used by nearly everyone, not only by trained university students.

Use of RPE Scale to Determine Exercise Intensity

The development of a scale for RPE was devised by Borg. The first was a 21-graded category scale to estimate work capacity (Borg, 1973). The RPE gave a very high correlation with absolute HR ($r = .80 - .90$) in a variety of work tasks (bike and treadmill, and arm and leg work), in healthy people when the work intensity was varied from light to heavy work (Borg, 1962). The scale made interindividual comparisons possible.

The scale was later changed to a 15-point scale with numbers

ranging from 6 to 20 (see Appendix A). Descriptive words are included with every other number, beginning with 7 at very, very easy, to 19 at very, very hard. The scale was revised to increase the linearity between RPE and HR with exercise intensity. The RPE values follow the heart rates very closely. Borg states:

For healthy middle-aged men doing moderate to hard work on a bicycle ergometer or treadmill, the heart rate should be about ten times the RPE value, i.e., with an RPE of 13, HR should be approximately 130 beats per minute (Borg, 1982, p. 91).

However, because the RPE scale was developed with healthy middle-aged men, Williams and Eston (1989) felt it was not universally applicable.

In patients with coronary artery disease (CAD), ratings of perceived exertion were found to be as reliable as heart rate. Borg and Linderholm (1970) found that RPE was as reliable as heart rate in two cycling workloads which corresponded to heart rate levels of 130 and 170 bpm both in men and women who had suffered cardiovascular disease and in a control group of healthy age-matched subjects.

Ratings of perceived exertion levels of 12 to 16 (somewhat hard to hard) on the Borg 15-point scale are claimed to be equivalent to between 50 and 85% of a person's VO_{2max} (ACSM, 1991). Eston, Davies, and Williams (1987) had 28 fit individuals (16 men and 12 women) run at constant exercise intensities which their perceived exercise intensities corresponded to 9, 13, and 17 on the Borg scale. Results from this study showed that all the participants were within 59 to 84% of their VO_{2max} when their estimated effort was a RPE of 13 on the Borg scale. The authors concluded that the RPE scale is an useful index of appropriate exercise intensity when used by healthy and active

individuals. In a study conducted by Demmello et al. (1987) RPE at the lactate threshold (RPE LT) and at various percentages of $\text{VO}_{2\text{max}}$ were compared in trained distance male and female runners and untrained subjects. The maximal oxygen consumption of the trained men and women was significantly higher than for the untrained men and women. Similarly, the mean lactate thresholds (LTs) of the trained men and women were significantly higher than for the untrained men and women. It was concluded that LT is an important physiological anchor point for perception of effort that is not affected by state of training. Trained and untrained men and women perceive the exercise intensity at LT as "somewhat hard" (RPE = 13 to 14) on Borg's 15-point scale. During moderate-to-heavy exercise intensities, RPE is more closely linked to the metabolic and gas exchange alterations initiated at the LT than to % $\text{VO}_{2\text{max}}$ utilized.

Robertson et al. (1990) determined the validity of cross-modal prescription of exercise intensity based on RPE for eight men of absolute and relative VO_2 . Exercise modes were treadmill (TM), cycle ergometer (C), and bench stepping while pumping handweights (HB). They found RPE-overall during TM-relative (11.1) was a). lower ($p > .05$) than C-absolute (12.6) and HB-absolute (12.5) and b). the same as C-relative (11.3) and HB- relative (10.7). Robertson et al. (1990) concluded that perceptually based cross-modal prescription of exercise intensity using a psychophysical estimation method is valid provided that the physiological reference is the relative, not the absolute VO_2 .

Validity of Borg's Rating Scale of Perceived Exertion

The Borg Scale has been proven valid and reliable in repeated tests of increasing work intensity with work loads either progressively or randomly ordered. In a single motor performance, high correlations have also been found between perceived exertion and produced force (Cooper, Grimby, Jones, & Edwards, 1979). At constant intensities and low work, low correlations from .20 to .50 between RPE and HR have been found (Skinner, et al., 1973a; Smutok, Skrinar & Pandolf, 1980). Since the RPE scale provides values that increase linearly with work load and heart rates, Borg suggested that the 15-point scale with numbers from 6 to 20 be used for consistency.

A number of studies have shown the validity and reliability of Borg's 15-point scale (Borg & Noble, 1974; Morgan, 1973; Skinner et al. (1973a); Stamford, 1976). Skinner et al. (1973a) found that all reliability coefficients, with the exception of respiratory rate and tidal volume were significant. The reliability coefficients ranged from $r = .78$ - $r = .96$. There were also no significant differences between the random and progressive tests.

Skinner et al. (1973a) concluded that there were no significant differences in the physiological or perceptual variables studied between the progressive and random tests. Therefore, the progressive tests seem to have high reliability and validity and also take less time. Stamford (1976) evaluated the reliability and validity of perceptual responses of 14 sedentary females. The exercise intensities were varied and randomly presented. A high linear relationship was shown between HR response and RPE. The findings indicated that RPE readings were reliable and valid, independent of exercise intensity.

Other studies have repeated and replicated the outcomes to Borg's RPE scale in regard to work load and physiological parameters during

exercise (Ekblom & Goldbarg, 1971; Morgan, 1973; Noble et al., 1973).

In the work of Borg and Linderholm (1970) the reliability of the measurements of physical working capacity (PWC) based on ratings of exertion were compared to those on HR in a group of 54 healthy male subjects. Intratest correlations were determined by correlating two different PWC(130) measurements. A reliability coefficient of .91 was found. In the same way, the reliability of PWC(13) (RPE at 13) measurements were calculated and found to be .92. Test-retest reliability coefficients were also determined in a mixed group of 19 patients and a group of 17 healthy subjects. The PWC(13) and PWC(170) test-retest coefficients were .93 and .98, respectively, in the patients, and .88 and .97, respectively, in the healthy subjects. The corresponding PWC (R13) and PWC (R17) coefficients were .80 and .94, respectively, in the patients, and .91 and .98, respectively, in the healthy subjects. These coefficients show that the reproducibility, based on repeated measures, is as good for the PWC(R) measurements as for the PWC(HR) measurements (Borg & Linderholm, 1970).

The effect of possible cultural differences on the HR-RPE relationship has been considered. In studies conducted by Skinner, Borg and Buskirk (1969) and Bar-Or et al. (1972), the same linear relationship between RPE and HR was found on university-aged American males and on middle-age American males as found with Swedish samples. Borg (1982) suggests that one perfect scale useful in all situations for perceptual rating may not exist. This may be a concern in the clinical setting with regard to exercise prescription.

Therapeutic Implications

Exercise Evaluation

Rating of perceived exertion may provide important diagnostic information. When used alone or in combination with HR, RPE can be used to predict $\dot{V}O_{2\max}$. A study by Morgan and Borg (1976) found that the prediction of maximal work capacity from both HR and RPE is more accurate (multiple $R = .73$) than from HR alone ($R = .65$). These authors suggest that a combined RPE-HR model is more accurate in the prediction of maximal exercise capacity than the separate use of RPE or HR. This may be clinically important, since maximum HR and working capacity are not always obtained in patients with cardiovascular disorders. Thus, RPE could improve the accuracy and safety in the evaluation of diagnostic testing to determine exercise tolerance in cardiac patients. In contrast, Skinner, Hutsler, Bergsteinova, and Buskirk (1973b) found patients with coronary artery disease (CAD) elicited higher RPE's in relation to HR than those in a control group of healthy subjects working at similar work loads. Squires, Rod, Pollock, and Foster (1982) found that cardiac patients on propranolol have a lower heart rate during submaximal and maximal exercise when compared with those not receiving propranolol, but RPE was the same for both groups at similar work loads. Borg and Linderholm (1970) analyzed the relationship between HR and RPE during tests in thousands of cardiac patients. Three groups were analyzed: patients with CAD, patients with arterial hypertension, and patients with vasoregulatory asthenia syndrome. Patients with vasoregulatory asthenia and patients with arterial hypertension rated the exertion to be less in relation to HR than healthy controls,

than healthy controls, particularly at low levels. On the contrary, patients with CAD rated the exertion to be higher, particularly at high ratings, in relation to HR. In all the groups studied, there was a smaller increase in HR relation to a given increase in RPE.

Turkulin et al. (1977) showed that RPE in relation to exercise intensity was higher for 50 myocardial infarction (MI) patients than for untrained healthy subjects or sportsmen. The RPE and exercise intensity was more highly correlated in the sportsmen ($r = .82$), and untrained men ($r = .72$) than in the myocardial infarction patients ($r = .57$). In this study, both MI patients and untrained healthy subjects showed the tendency to overestimate the exertion in relation to HR, while the trained subjects underestimated the level of exertion, consistent with the findings of Borg and Linderholm (1970). The authors concluded that RPE may provide additional information on patients who remain at moderate levels of working capacity in defining their subjective exercise tolerance limit. Roitman, Feldpausch, and Leguizamon (1982) conducted a study on RPE before and after four weeks of exercise training immediately following CABGS in 12 male patients. Results of the training program showed that while RPE increased significantly ($p < .01$) at absolute workloads. There was no other significant difference in RPE ($p > .05$) at relative workloads. Peak HR and submaximal workload at the same HR increased as a result of training. It was concluded that RPE may not show the changes previously reported with training in early post-CABGS patients. The authors mentioned that intervening variables such as effects of medications, sinus tachycardia secondary to postsurgical hypovolemia, and the psychological effects of surgery and

hospitalization may moderate to buffer these changes during the early exercise therapy (Roitman et al., 1982). Williams and Fardy (1979) demonstrated the limitations in prescribing exercise from perceived exertion, onset of symptoms, or fixed HRs in 10 cardiac patients. The mean RPE value was an 11 or "fairly light" on the Borg 15-point scale. The authors found that of 10 cardiac patients tested, 5 developed ST-segmental changes, and 5 patients displayed the onset of potentially lethal dysrhythmia. The investigators concluded that exercise prescriptions according to RPE, onset of symptoms, or a low level fixed HR could have been dangerous in these patients.

Exercise Prescription

Borg suggested that the most interesting application of perceived exertion was in the area of exercise prescription. In recent years, perceived exertion has become an important measure in the clinical evaluation and/or graded exercise testing (GXT) in both healthy patients and patients with cardiovascular disorders. Within the past few years, several adult fitness and cardiac rehabilitation programs have been using RPE in prescribing the exercise training intensity. Rate of perceived exertion has wide applicability in both exercise prescription and in monitoring of training effects. Pollock, Ward, and Foster (1979) found that in addition to RPE having potential value in diagnostic testing, RPE could be used in exercise prescription and in monitoring training effects. The authors also claim that target HRs of 70 to 85% of maximum HR reserve are widely accepted as appropriate levels for training and rehabilitation.

The work of Smutok et al. (1980) looked at the relationship of RPE

and HR during an original GXT (T1), and in subsequent tests (T2 & T3) 10 normal male subjects were asked to reproduce speeds at various RPE levels recorded in the original test. The results showed no significant differences at HR levels above 150 bpm (18% HRmax) and RPE above 12. Rate of perceived exertion at lower HRs were significantly different in T1 from those in T2 and T3. A RPE of 10 during T1 was associated with a HR of about 121 while the same RPE during T3 was related to a HR of 136. The authors suggest that the use of RPE for the prescription of exercise below these levels results in inaccurate and unreliable target HR responses. Therefore, Smutok and his colleagues concluded the implication in using RPE to prescribe exercise is potentially dangerous for cardiac patients.

The study by Gutmann et al. (1981) determined the relationship between RPE and HR during GXT's and training in 20 male myocardial revascularization surgery (MRS) patients at 2 and 8 weeks after surgery, and also to evaluate how RPE relates to proposed target HRs. At 2 and 8 weeks after MRS, patients perceived exercise at matched HRs in GXT and training to be the same. The authors concluded:

RPE does seem to bear a constant relationship to HR in both GXT and training early in rehabilitation (Gutmann et al., 1981, p.57).

Squires et al. (1982) evaluated the effects of propranolol on RPE during graded exercise testing (GXT) soon after myocardial revascularization surgery (MRS). The results of the study indicated that propranolol did not affect RPE during graded exercise testing in the selected cardiac patients. The propranolol group demonstrated a lower HR for submaximal and peak exercise when compared with the

nonpropranolol group, but RPE was the same for matched exercise intensities. Therefore, propranolol does not affect RPE during GXT soon after cardiac surgery. The use of RPE with patients during the first several days after MRS has been previously reported by Gutmann et al. (1981) indicating that RPE may be helpful in designing exercise programs and in determining appropriate GXT end-points soon after surgery for patients who are either taking or not taking propranolol.

The RPE scale was designed to follow the HR response to increasing exercise intensities. A number of studies have examined the influence of beta-adrenergic receptor blocking agents on RPE. Past research (Davies & Sargeant, 1979; Ekholm & Goldbarg, 1971; Pandolf, Cafarelli, Noble, & Metz, 1972; Skinner et al., 1973b) relating to RPE and HR during exercise, showed that moderate doses of propranolol do not alter RPE at given relative exercise intensities in cardiac patients.

Sensory Cues and RPE

The manner in which sensory inputs are monitored and integrated to determine perceived exertion remains unclear. Ekholm and Goldbarg (1971) were the first to propose a two-factor model for evaluation of perceived exertion during physical work. They proposed that perception of effort during different forms of physical work was governed by "local" and "central" factors. Local factors refer to the feeling of strain in the working muscles and joints, while central factors consist of breathing and HR (perceived tachycardia, tachypnea, and dyspnea). O'Sullivan (1984) states:

Kinesthetic information arising from proprioceptive mechanism (mechanoreceptor, golgi tendon activity, and sensations from muscle, ligament, joint and skin) provides an important source of local cues (O'Sullivan, 1984, p. 344).

A study conducted by Noble et al. (1973) suggests local muscle usage is involved in the perception of exertion. Perceptual and metabolic responses to walking and running at similar velocities between 2.5 and 5.5 mph were investigated. Rate of perceived exertion values showed a similar pattern to HR, however, HR (4.92 mph) was significantly higher than for RPE (4.31 mph). The authors proposed that the local muscular discomfort of the working muscle was responsible for the difference between RPE and activities. Physical strain in the working muscles may also be perceptually prominent at higher workloads if mechanical efficiency is poor. This was demonstrated by Horstman, Morgan, Cymerman, and Stokes (1975) who found local RPE to more markedly dominate central RPE when walking was compared to running, at 80% $\text{VO}_{2\text{max}}$. While HR and RPE may be highly correlated, it has not been implied that these measures are casually related. Several studies have compared cycling with running and have found that at a given submaximal uptake, RPE is higher for bicycling than running (Ekholm & Goldbarg, 1971; Skinner et al., 1973b). Ekholm and Goldbarg (1971) state:

The higher RPE scoring for a given submaximal work on the bicycle may be caused by the higher local muscular strain, indicated by higher blood lactate concentration (p. 405).

They concluded that RPE will be the same in cycling and running when related to relative oxygen uptake.

Mihevic (1981) summarized the factors underlying the perception of effort by stating:

Consideration of modifying variables for the exercise response, such as exercise intensity, exercise duration, exercise modality, and response time suggests that rather than a single primary cue, multiple sensory inputs of local and central origin are integrated and weighted by the individual to arrive at an elevation of overall perceived exertion (p. 161).

Summary

Medically supervised physical exercise is the main element of cardiac rehabilitation (Leon et al., 1990). The goal of cardiac rehabilitation is to enable the patient to achieve maximal functional capacity and to resume active and productive lives upon return to the home environment for as long as possible (Leon et al., 1991; Squires et al., 1990). A multidisciplinary healthcare team consisting of cardiologists, exercise physiologists, nurses, dieticians, and physical and occupational therapists all play an important role in carrying out these goals involved in cardiac rehabilitation. The rehabilitation process for cardiac patients is divided into three phases: Phase I: the hospital inpatient period, Phase II: outpatient rehabilitation, and Phase III: the supervised portion of the continued maintenance period.

Ratings of perceived exertion are being increasingly applied to evaluate, monitor, and prescribe the intensity of physical activity during clinical exercise testing, conditioning programs, occupational tasks, and athletic performance (Demmello et al., 1987). Borg developed the rating of perceived exertion to measure long-term changes in work capacity (Borg, 1962). Borg and Noble (1974) proposed perceived exertion to be a psychologic cue to physiological responses during exercise. These cues come in the form of both general feelings of fatigue and exertion. Borg (1982) states the HR should be about 10

times the RPE value for healthy middle-aged men doing moderate to hard work, but because this was developed with healthy middle-aged men, Williams and Eston (1989) feel the RPE scale is not universally applicable. Although there is not a perfect linear relationship between RPE and exercise intensity, the reliability coefficient of .90 suggests that the Borg 15-point scale appears to be useful in expressing perceptions experienced during prolonged bouts of exercise.

Recently, ACSM (1991) recommended RPE as a means of monitoring exercise intensity during GXT and controlling exercise intensity during endurance training. Eston et al. (1987) demonstrated that RPE was at least as good a predictor of exercise intensity as HR in both a GXT and an effort production test, particularly at two higher RPE levels of 13 and 17. Demmello et al., (1987) found that during moderate-to-heavy exercise intensities, RPE is more closely linked to the metabolic and gas exchange alterations initiated at the lactate threshold than to percent $\dot{V}O_{2max}$ utilized. Roitman et al. (1982) conducted a study on RPE before and after 4 weeks of exercise training immediately following CABG surgery in 12 male patients. Peak HR and submaximal workload of the same HR increased as a result of training. The authors concluded RPE may not show the changes previously reported with training early in post CABG surgery. In contrast, Gutmann et al. (1981) and Squires et al. (1982) indicated that RPE may be helpful in designing exercise programs and in determining appropriate GXT end-points soon after surgery. Pollock et al. (1979) found in addition to RPE having potential value in diagnostic testing, RPE could be used in exercise prescription and in monitoring of training effects. Robertson et al. (1990) found that

perceptually based cross-modal prescription of exercise intensity using a psychophysical method was valid provided that the physiological reference was the relative, not the absolute $\dot{V}O_2$. Further research is necessary regarding the use of the 15-point scale in cardiac rehabilitation patients.

The RPE scale provides an estimate of the subjective cost of physical activity that may or may not necessarily agree with the actual physiological indicators of physical activity (Borg, 1982). In healthy, young, and middle-aged subjects who exercise at moderate to high intensities, RPE was shown to be a direct measure of physiological stress and an indirect measure of physical working capacity (Borg, 1973; Ekblom & Goldbarg, 1971; Skinner et al., 1973a). A number of studies have shown the validity and reliability of Borg's 15-point scale in repeated tests of increasing work intensity (Borg & Linderholm, 1970; Borg & Noble, 1974; Cooper et al., 1979; Ekblom & Goldbarg, 1971; Morgan, 1973; Noble et al., 1973; Skinner et al. 1973a; Smutok et al., 1980; Stamford, 1976). Other studies have replicated the outcomes to Borg's RPE scale in regard to workload and physiological parameters during exercise (Borg & Linderholm, 1970; Ekblom & Goldbarg, 1971; Morgan, 1973; Noble et al., 1973). Skinner et al. (1969) and Bar-Or et al. (1972) considered the cultural differences on the HR-RPE relationship with university-aged American and Swedish males and found the same linear relationship between HR and RPE. Turkulin et al. (1977) found that RPE may provide additional information on patients who remain at moderate levels of working capacity in defining their subjective exercise tolerance limit. Morgan and Borg (1976) and Smutok et al.

(1980) feel a combined RPE-HR model is more accurate in the prediction of maximum exercise capacity than the separate use of RPE or HR. Williams and Fardy (1979) and Gutmann et al. (1981) found that at low HR's and low exercise intensity, RPE may not be a reliable indicator of HR. In patients with cardiovascular disorders and in certain environmental and drug situations where exercise was performed under irregular conditions, the relationship between HR and RPE appears to change (Borg & Linderholm, 1970; Davies & Sargeant, 1979; Pandolf et al., 1972; Skinner et al., 1973b). A number of studies that have looked at perceived exertion during physical work (Ekholm & Goldbarg, 1971; Horstman et al. 1975; O'Sullivan, 1984) proposed that perception of effort during different forms of physical work was governed by "local" and "central" factors. Mihevic (1981) suggest that multiple sensory inputs of local and central origin are integrated by the individual to arrive at an elevation of overall perceived exertion. Therefore, because each study has a different notion of the RPE scale, research on perceived exertion needs to be more fully applied in cardiac rehabilitation to evaluate its usefulness.

Future studies are needed to systematically determine specific criteria for progression and optimal levels at which to maintain various cardiac patient groups. The ability of the postcardiac patient to subjectively rate the perception of low to moderate levels of physical work during outpatient cardiac rehabilitation needs to be investigated more thoroughly. The relationship between RPE and intensity of exercise through Phase II cardiac rehabilitation remains of interest in terms of

both psychological and physiological adaptations that occur in exercise therapy after a cardiac event.

CHAPTER III

METHODS

Introduction

The purpose of this study was to determine the relationship between heart rate (HR) and rate of perceived exertion (RPE) among Phase II cardiac rehabilitation program participants with various modes of exercise. Specifically, the study investigated RPE response and its relationship to HR to determine if the RPE scale is a reliable measure of exertion with cardiac patients.

The presentation of the methods used to conduct this research project has been divided into three separate sections: subject selection, testing methods, and statistical treatment of data.

Subject Selection

Subjects for this investigation consisted of 100 Phase II cardiac patients, 77 males and 23 females. The sample consisted of surgical patients who underwent the following procedures: heart transplant, coronary artery bypass graft surgery (CABG), heart valve repair or replacement, percutaneous transluminal coronary angioplasty (PTCA), and automatic implantable cardiac defibrillator (AICD). Another segment of the sample group consisted of nonsurgical patients suffering from: myocardial infarction (MI) and cardiomyopathy. The mean age of the 100 subjects was 58.4 years. The study was conducted over a one month period (January, 1992). The 100 subjects were selected from files containing 360 charts of past cardiac rehabilitation Phase II patients.

The 100 subjects were randomly selected using the "fish-bowl" method (Witte, 1989). This method involved assigning a number, ranging from 1 to 360, to each chart until all 360 charts were designated a number. Corresponding numbers were deposited in a bowl and stirred. A number was drawn from the bowl, and that number designated the first chart to be included in the sample. If in the chart chosen, the patient did not participate in all 24 exercise sessions and all 4 exercise modes, the chart was discarded and the drawings were continued until 100 charts (100% attendance) were obtained.

Outpatient Cardiac Rehabilitation Phase II Program Overview

The early outpatient cardiac rehabilitation program, referred to as Phase II cardiac rehabilitation, began at the time of hospital discharge, usually two weeks after surgery. Prior to Phase II cardiac rehabilitation, the patients participated in the inpatient cardiac rehabilitation program (Phase I), which included controlled early ambulation, physical therapy, treadmill walking, and patient education stressing the relation of life-style to coronary artery disease (CAD). Ambulation and physical therapy began, in most cases, the day after surgery and continued until discharge from the hospital. The non-surgical patients (MI's and cardiomyopathys) performed treadmill walking and patient education sessions which also stressed the relation of life-style to CAD. Early outpatient rehabilitation involved close medical supervision for a period of 8-12 weeks. At the Milwaukee County Medical Complex (MCMC), early outpatient cardiac rehabilitation included instructing patients in proper exercise procedures, restoring them to a desirable exercise capacity appropriate to their clinical status,

life-style and occupation, and also to meet the psychosocial needs of patients and families.

The exercise program during Phase II cardiac rehabilitation varied somewhat for each patient, dependent on individual exercise prescriptions developed as a result of their level of physical fitness and/or clinical status. At the MCMC each patient is involved in aerobic exercise, such as treadmill walking and bicycle ergometer, and upper extremity exercises, such as arm ergometer and rowing machine, to best suit his/her occupational or recreational activities. All the participants in this study were involved in the supervised multimode exercise sessions. They were supervised 2-3 times a week, a total of 24 sessions, for 8-12 weeks, directly by the exercise physiologist(s).

Testing Methods

Shortly after discharge, usually two weeks, patients were referred to the hospital-based outpatient Phase II cardiac rehabilitation program. The purpose of the program was explained by an exercise physiologist and signed informed consent for all exercise training and testing procedures was obtained through the Phase II cardiac rehabilitation program entry procedures. This informed consent included an explanation of the cardiac rehabilitation program and the procedures involved in the program (see Appendix B).

The Phase II program included 2-3 sessions per week in the cardiac rehabilitation exercise laboratory, supervised directly by three exercise physiologists and a cardiac rehabilitation nurse. Continuous electrocardiographic (EKG) monitoring occurred during each exercise session. Heart rate was measured with telemetry recorded EKG tracings

using a single lead tracing. This type of monitoring is helpful in observing dysrhythmias and ST-segment changes. Rate of perceived exertion was determined through the subjects self report of the Borg 15 point scale ratings. The concept of RPE was explained and used routinely during each exercise session. The scale provides a rating of the degree of overall effort that is helpful in teaching patients proper exercise pacing. The patients were asked to select the number that best applied to the subjective sensation of effort at a given workload. They were specifically instructed not to attend to a single sensation such as leg or chest wall discomfort, but to base the rating on the total exertion felt (ACSM, 1991). Assessments were made during exercise at four different exercise modes for each subject on four separate days. Exercise modes included Marquette Electronics motor driven treadmills, Monarch bicycle ergometers, Avita rowing machine, and a Monarch arm ergometer (see Appendix C). Heart rate and RPE data were obtained from the exercise physiologist during the final 2 minutes of each exercise interval. During the 12 week rehabilitation program, the subjects were periodically retested (approximately every 4 weeks) by the exercise physiologist on their exercise training modalities. This was conducted to evaluate the health status of the patients cardiovascular-respiratory system, to note their response to the Phase II cardiac rehabilitation program, and to update their exercise prescription.

Data Collection

The data were collected by the exercise physiologists at the MCMC and placed in each patients individual chart. The investigator conducting the research study reviewed and collected data from the

charts of 100 cardiac rehabilitation patients. The patients charts were randomly chosen through the fish-bowl method. The data was collected over a 1 month period (January, 1992). The investigator examined the relationship between HR and RPE of the 100 subjects in 4 different exercise modes over 4 exercise sessions. The exercise sessions consisted of sessions 2, 3, 23, and 24. The researcher chose these four representative exercise sessions to determine if the RPE scale is a reliable measure of exertion early in the rehabilitation program as well as in the later sessions of the rehabilitation program. If the findings revealed a significant relationship between HR and RPE with all four exercise sessions, the researcher could conclude the subjects could subjectively regulate intensity during exercise based on the RPE scale. If the findings revealed no significant relationship between HR and RPE with all four exercise sessions, the researcher could conclude the subjects exhibited little awareness regarding intensity during exercise based on the RPE scale.

Statistical Treatment of Data

The following statistical techniques were used for data analysis:

1. A total of 1,600 paired scores were analyzed.
2. A Pearson product-moment correlation was performed between HR and RPE for each exercise mode in all four exercise sessions.

The level of significance was set at .05.

CHAPTER IV

RESULTS AND DISCUSSION

Introduction

This study was conducted to determine the relationship between heart rate (HR) and rate of perceived exertion (RPE) among Phase II cardiac rehabilitation program participants with various modes of exercise. Heart rate was determined with telemetry recorded EKG tracings. Rate of perceived exertion was determined through the subjects self report of the Borg Rating of Perceived Exertion Scale (Borg, 1982). The statistical analysis focused on whether or not there was a significant relationship between HR and RPE on four different exercise modes for each subject during four separate exercise sessions.

Subject Characteristics

The physical characteristics of the 100 subjects, 76 males and 24 females, who completed the study are presented in Table 1. These characteristics include the subjects' age, height, and weight. The subjects' medical reasons for participating in the cardiac rehabilitation program are presented in Table 2.

Results of the Study

The relationship between HR and RPE was determined using a Pearson product-moment correlation. Results of the study are presented in four separate tables, Tables 3-6. Each table represents the relationship found between HR and RPE during exercise at four different exercise modes.

Table 1. Physical characteristics of the subjects

Variable	Males (n = 76)	Females (n = 24)
Age (years)	58.9 \pm 11.45	57.1 \pm 12.0
Height (in)	69.1 \pm 2.36	65.2 \pm 2.13
Weight (lbs)	184.7 \pm 11.34	156.8 \pm 13.64

Note. All values represent mean \pm standard deviation.

Table 2. Events leading to entrance into the cardiac rehabilitation program

Events	Frequency	
	(males)	(females)
Heart Transplant	2	0
Myocardial Infarction (MI)	20	9
Coronary Artery Bypass Graft (CABG)	16	3
CABG & MI	21	3
Percutaneous Transluminal Coronary Angioplasty (PTCA)	1	1
PTCA & MI	7	2
Valve repair or replacement	5	1
CABG & valve	0	2
CABG & MI & PTCA	1	1
Cardiomyopathy	2	1
Automatic Implantable Cardiac Defibrillator (AICD)	1	1

Exercise Session Two

A significant ($p < .05$) relationship between HR and RPE was found with the treadmill ($r = .23$) and rowing machine ($r = .21$). The results of the analyses are presented below in Table 3. These findings indicated the subjects could subjectively regulate their intensity during exercise based on the RPE scale. Therefore, the RPE scale was found to be a reliable measure of exertion with the treadmill and rowing machine only. No significant relationship between HR and RPE was found with the bike ergometer ($r = .08$) or arm ergometer ($r = .06$). These findings indicated the subjects exhibited little awareness regarding their intensity during exercise based upon the RPE scale. Thus, the RPE scale was not a reliable measure of exertion with the bike or arm ergometer.

Table 3. Results of exercise session two

Exercise Mode	Mean	S.D.	r
Treadmill			.23*
HR	104 ±	16.0	
RPE	12 ±	1.4	
Bike Ergometry			.08
HR	105 ±	18.2	
RPE	13 ±	10.2	
Arm Ergometry			-.06
HR	99 ±	18.7	
RPE	13 ±	10.2	
Rowing			.21*
HR	101 ±	18.4	
RPE	12 ±	1.5	

S.D. = Standard deviation

r = Pearson correlation coefficient

* = Significant relationship between HR and RPE ($p < .05$)

Exercise Session Three

Results of the analyses of exercise session three are presented below in Table 4. Test results indicated no significant relationship between HR and RPE with any of the four exercise modes. Based upon the RPE scale, subjects indicated little awareness regarding intensity during exercise. Therefore, the RPE scale was not found to be a reliable measure of exertion.

Table 4. Results of exercise session three

Exercise Station	Mean		S.D.	r
Treadmill				.13
HR	105	±	16.1	
RPE	12	±	1.2	
Bike Ergometry				.01
HR	106	±	17.8	
RPE	13	±	10.1	
Arm Ergometry				-.01
HR	98	±	17.6	
RPE	13	±	10.2	
Rowing				.10
HR	102	±	17.6	
RE	12	±	1.4	

S.D. = Standard deviation

r = Pearson correlation coefficient

Exercise Session Twenty-Three

The results for session twenty-three were similar to session three. Results of the analyses of session twenty-three are presented below in Table 5. There was no significant relationship between HR and RPE in any of the four exercise modes. These findings indicated the subjects exhibited little awareness regarding their intensity during exercise based upon the RPE scale. Thus, the RPE scale was not a reliable measure of exertion.

Table 5. Results of exercise session twenty-three

Exercise Mode	Mean		S.D.	r
Treadmill				.00
HR	109	±	17.1	
RPE	12	±	1.2	
Bike Ergometry				.15
HR	109	±	17.2	
RPE	12	±	1.1	
Arm Ergometry				-.05
HR	103	±	17.8	
RPE	12	±	1.3	
Rowing				.04
HR	102	±	17.4	
RPE	12	±	1.3	

S.D. - Standard deviation

r - Pearson correlation coefficient

Exercise Session Twenty-Four

Results for exercise session twenty-four were similar to exercise sessions three and twenty-three. The analyses of session twenty-four are presented below in Table 6. There was no significant relationship between HR and RPE in any of the four exercise modes. These findings indicated the subjects exhibited little awareness regarding their intensity during exercise based upon the RPE scale. Therefore, it can be concluded the RPE scale was not a reliable measure of exertion.

Table 6. Results of exercise session twenty-four

Exercise Mode	Mean		S.D.	r
Treadmill				.03
HR	110	±	17.7	
RPE	12	±	1.3	
Bike Ergometry				.04
HR	110	±	17.9	
RPE	12	±	1.4	
Arm Ergometry				-.10
HR	103	±	17.7	
RPE	12	±	1.1	
Rowing				.04
HR	102	±	18.0	
RPE	11	±	1.3	

S.D. - Standard deviation

r - Pearson correlation coefficient

Discussion of Results

This study was designed to determine the relationship between HR and RPE among Phase II cardiac rehabilitation program participants with various modes of exercise. Upon examining the statistical analyses, a significant relationship between HR and RPE resulted in only one of the four exercise sessions. This relationship occurred in session two with the treadmill and rowing machine. These results indicated the subjects could subjectively regulate their intensity during exercise in session two only, based upon the Borg 15-point scale ratings.

Borg and Linderholm (1970) found that RPE is as reliable as HR in two cycling workloads which corresponded to HR levels of 130 and 170 bpm in patients who suffered cardiovascular disease and in a control group of healthy age-matched subjects. Pollock et al. (1979) found that in addition to RPE having potential value in diagnostic testing, RPE could be used in exercise prescription and in monitoring training effects. Gutmann et al. (1981) determined the relationship between RPE and HR during graded exercise tests and in training in 20 male myocardial revascularization surgery patients, and also to evaluate how RPE related to proposed target HR's. The investigators found RPE to bear a constant relationship to HR in both graded exercise testing (GXT) and training in rehabilitation. Morgan and Borg (1976) found that the prediction of maximal work capacity from both HR and RPE is more accurate (multiple $r = .73$) than from HR alone ($r = .65$). These authors suggest that a combined RPE-HR model is more accurate in the prediction of maximal exercise capacity than the separate use of RPE or HR. This may be clinically important, since maximum HR and working capacity are not

always obtained in patients with cardiovascular disease, as in the present study. These findings are similar to the results of the treadmill and rowing machine in exercise session two with the present study, indicating the RPE scale could be used with cardiac rehabilitation patients as a means of monitoring and controlling exercise intensity during training.

No significant relationship between HR and RPE occurred with the bike or arm ergometer in session two, or in any of the four exercise modes in sessions 3, 23, and 24. These results indicate as the subjects progressed through Phase II cardiac rehabilitation they exhibited little awareness regarding their intensity during exercise based upon the RPE scale. Borg (1973) and Skinner et al. (1973a) found RPE will differ depending on modality, intensity, and duration of the activity. Perhaps these factors may explain why the RPE scale was not found to be a reliable measure of exertion in the above exercise sessions. Another possible factor contributing to the nonsignificant relationship between HR and RPE could be due to the subjects overrating or underrating their exercise intensity. This inaccuracy in the rating of exercise intensity could be contributed to the subjects not receiving early emphasis and instruction on the use of the RPE scale. The instruction of the RPE scale enables the subjects to develop an awareness of a specific sensation or RPE. Through early education in the use of the RPE scale on a daily basis, the patient could be taught to subjectively monitor their response to increasing workloads. In this educational process, the awareness of the accompanying definition (i.e., RPE of 13 relates to "something hard") of the RPE value may be as important as the use of the

numbering system. Borg and Linderholm (1970) and Turkulin et al. (1977) analyzed the relationship between HR and RPE during test in thousands of cardiac patients. The authors reported that patients with coronary insufficiency and/or myocardial infarction overrate exercise intensity. They consistently rate higher RPE's for a given HR than a group of age-matched control subjects. Williams and Fardy (1979) demonstrated the limitation in prescribing exercise from perceived exertion, onset of symptoms, or fixed HR in cardiac patients. The mean RPE value was an 11 or "fairly light" on the Borg scale. The investigators concluded that exercise prescriptions according to RPE, onset of symptoms, or a low fixed HR could have been dangerous in these patients. Smutok et al. (1980) examined the relationship of RPE and HR during an original GXT and in subsequent tests where 10 normal male subjects were asked to reproduce speeds at various RPE levels recorded in the original tests. Smutok and his colleagues concluded the implication in using RPE to prescribe exercise for cardiac patients is potentially dangerous. These studies are similar to the results of exercise sessions 3, 23, and 24 in the present study. Therefore, because no significant relationship between HR and RPE was found in the present study, it can be concluded that the RPE scale is not a reliable measure of exertion with cardiac rehabilitation exercisers.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

The primary purpose of this study was to determine the relationship between heart rate (HR) and rate of perceived exertion (RPE) among Phase II cardiac rehabilitation program participants with various modes of exercise. One hundred subjects were randomly selected from a Phase II cardiac rehabilitation program. The variables analyzed included HR, which was measured with telemetry recorded EKG tracings, and RPE, which was determined through subjects self reports of Borg scale ratings. Assessments were made during exercise at four different exercise modes for each subject during four separate exercise sessions. Exercise modes included Marquette Electronics motor driven treadmills, Monarch bike ergometers, a Monarch arm ergometry, and an Avita rowing machine.

The statistical analysis included means and standard deviations for the physical characteristics of all subjects and the medical reasons for participating in the cardiac rehabilitation program. The data were analyzed to determine if the RPE scale is a reliable measure of exertion with cardiac patients. Statistical analyses were performed using a Pearson product-moment correlation. The significant level was set at .05 for all analyses.

Results showed a significant ($p < .05$) relationship between HR and RPE with the treadmill and rowing machine during exercise session two. No significant relationship between HR and RPE was found with the bike

or arm ergometer during session two. There was also no significant relationship between HR and RPE with any of the exercise modes on session 3, 23, and 24.

Conclusions

Based on the statistical analyses of the data the following conclusions were reached:

1. The RPE scale is not a reliable measure of exertion with cardiac Phase II patients.
3. Based upon the Borg 15-point scale, Phase II cardiac rehabilitation patients exhibit little awareness regarding intensity during exercise.

Recommendations

Based upon the results of this investigation, the following recommendations for future studies are made:

1. A similar investigation should be performed on two separate days every week during the 8-12 week Phase II cardiac rehabilitation program to determine the relationship between HR and RPE.
Rationale: Investigation of additional exercise sessions may reach more varied results.
2. A similar study should be conducted examining the relationship between RPE and MET levels during Phase II cardiac rehabilitation.
Rationale: Incorporating MET levels could possibly demonstrate the subjects capability of performing more work at the same RPE.
3. A study should be conducted examining the relationships between psychological changes (depression, anxiety, fear) and RPE

during Phase II cardiac rehabilitation.

Rationale: The psychological states of the subjects may have implications on RPE from the first exercise session.

4. A similar study should be conducted examining learning effects on RPE.

Rationale: To examine if the subjects, as they progress through the Phase II cardiac rehabilitation program are capable of gaining understanding of RPE, and thus possibly creating a correlation between HR and RPE.

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APPENDIX A

BORG SCALE OF PERCEIVED EXERTION

Borg Scale of Perceived Exertion

- 6
- 7 Very, very light
- 8
- 9 Very light
- 10
- 11 Fairly light
- 12
- 13 Somewhat hard
- 14
- 15 Hard
- 16
- 17 Very hard
- 18
- 19 Very, very hard
- 20

(Borg, 1973, p. 92)

APPENDIX B
INFORMED CONSENT



MILWAUKEE COUNTY
medical complex

8700 West Wisconsin Avenue

Milwaukee, WI 53226

414-257-7900, TTY 257-5774

I desire to engage voluntarily in the Cardiac Rehabilitation Program in order to attempt to improve my cardiovascular function. This program has been recommended and approved by my physician, Doctor _____ . Before I enter this exercise program I will have a clinical evaluation. This evaluation will include a medical history and physical examination consisting of, but not limited to, measurements of heart rate and blood pressure, EKG at rest and with effort. The purpose of this evaluation is to attempt to detect any condition which would indicate that I should not engage in this exercise.

The exercise sessions that I will become involved in will follow a personalized exercise prescription based upon the laboratory evaluation as well as my clinical history, and will be carefully regulated on the basis of my exercise tolerance. The exercise activities are designed to place a gradually increasing work load on the cardiovascular system and thereby improve its function. The reaction of the cardiovascular system to such activities cannot risk of certain changes occurring during or following the exercise. These changes include abnormalities of blood pressure or heart rate, or ineffective "heart function", and in rare instances, "heart attacks" or cardiac arrest.

Before initially participating in the exercise phase of the Cardiac Rehabilitation Program, I will be instructed regarding the signs and symptoms that I should report promptly to the supervisor of the exercises and that will alert me to modify my activities. I will be observed by the supervisor of the exercises, or an assigned assistant, who will be alert to changes that would suggest that I modify my exercise. Every effort will be made to avoid such events by the entrance interview, the preliminary medical examination (laboratory examination) and by the observations made during the exercise sessions. Emergency equipment and trained personnel are available to deal with and minimize the dangers of any immediate resuscitation measures deemed advisable by the supervisor of exercise.

The information that is obtained during the laboratory evaluations and exercise sessions of the Cardiac Rehabilitation Program will be treated as privileged and confidential, and will not be released or revealed to any nonmedical person without my expressed written consent. The information obtained, however, may be used for a statistical or scientific purpose with my right of privacy retained. I also approve of periodic forwarding to my physician of data relative to the laboratory evaluation(s) and my involvement in the exercise sessions.

I have read the foregoing and I understand it. Any questions that have arisen or occurred to me have been answered to my satisfaction.

Date _____

Patient _____

Program Director _____

DIVISION OF CARDIOLOGY 2516 - 1
TELEPHONE 414 - 257-6070

APPENDIX C

MULTISTAGE EXERCISE FORM

MULTISTAGE EXERCISE FORM

EXERCISE MODE	WORKLOAD	PERCEIVED EXERTION	HEART RATE
Treadmill	____ MPH ____ %	_____	_____
Bike	____ kpm	_____	_____
Arm Ergometry	____ watts	_____	_____
Rowing	____ watts	_____	_____

Name _____ Age _____

Cardiac Event _____ Weight _____

Exercise Session _____ Height _____