REVIEW OF LITERATURE

2.1 CARDIAC REHABILITATION:

Cardiac Rehabilitation (CR) is an interdisciplinary program including exercise training reducing mortality and morbidity (Oldridge, Guyatt et al. 1988, O'Connor, Buring et al. 1989).

The beneficial effect of secondary prevention, including lifestyle adaptations, is well documented (Ornish 1993, Haskell, Alderman et al. 1994, Linden, Stossel et al. 1996, Niebauer, Hambrecht et al. 1997). The reports on health economic aspects show that cardiac rehabilitation is a justifiable use of the health-related budget (Levin, Perk et al. 1991, Oldridge, Furlong et al. 1993, Ades, Pashkow et al. 1997). However, access to cardiac rehabilitation is often limited.

2.2 HISTORICAL PERSPECTIVE:

Cardiovascular diseases are one of the leading causes of mortality. They also induce lead to irreversible physical functional capacity and other disabilities. After an event of any cardiac illness, till 1950’s patients were advised six months bed rest. The concept of early mobilization developed by Samuel Levine and Newman and the development of inpatient physical activity program by Wilhelm Raab et al (Oberman, Wayne et al. 1982) were remarkable milestones in Cardiac rehabilitation.
Later, the guidelines for cardiac exercise training program were developed by American college of Sports Medicine and American Heart Association (Leon, Franklin et al. 2005, Thomas, King et al. 2007).

Modified Cardiac Rehabilitation programs for patients undergoing Coronary Artery Bypass Grafting surgery (CABG), valve surgeries (both adult and children), Correction of congenital Anomalies, those with Cardiomyopathy, Cardiac failure and patients with implanted cardiac pacemakers and defibrillators were developed. (Foxworth 1978, Farin, Dudeck et al. 2007). Gradually, exercise training had become one of the required aspect of management after a Coronary event i.e. Coronary Artery Bypass Grafting surgery (CABG) (Graves and Pollock 1993, Wenger 1996).

2.3 DEVELOPMENTS IN CARDIAC REHABILITATION:

Several approaches have been developed across globe to improve the outcomes of Exercise training programs. Multidisciplinary approaches were widely used with graded exercises training and early ambulation training. Educational training and psychological support have gained importance to be incorporated in Cardiac Rehabilitation. (R.Mulcahy16)(Mathes 1999)(Eagle, Guyton et al. 1999).
Multidisciplinary nature of the modern CR program (Eagle, Guyton et al. 1999)

Hospital based training with four weeks of exercise training and psycho-social support was widely implemented initially. Exercise based training emerged as primary basis for Cardiac Rehabilitation (Hellerstein and Ford 1957). Psychological counseling and social support also were considered as an essential component of CR training program.

Cardiac Rehabilitation arena expanded from adult to pediatric population for different types of cardiovascular disorders. With ever expanding patient population, gradually group therapy was applied for increased utility across patients.
The advancement in medical facilities and surgical techniques have significantly improved survival rate and hence paving way for greater demand for patient physical capacity building to have longer and functional quality life. Wider application of Cardiac rehabilitation programs among varied patient population evolved the need of a scientific and systematic training mostly done under supervision/monitoring.

Rehabilitation methods are incorporated into the existing healthcare system suitable to their cultural traditions and social norms. Education is also needed on maintain cardiovascular health, particularly for those undergoing social transition, with adaptable changes made in their culture, foods, lifestyle, and economics.

The spectrum of coronary disease is extended to include acute myocardial reperfusion with coronary thrombolysis and/or early coronary angioplasty or coronary bypass surgery as well patients having severe end-stage coronary heart disease. One of the major advancement is the availability of safe methods to stratify Cardiac risk. It serves as a guide to the resumption of work and other pre-illness activities Bjarnason-Wehrens (Corra, Giannuzzi et al. 2005, Bjarnason-Wehrens, Grande et al. 2007, Bjarnason-Wehrens, McGee et al. 2010).

Presently, the benefits of any intervention includes enhancing quality of life, also improving perception of patients in relation to physical, social, and
emotional status. Cardiac Rehabilitation is found to improve QOL to larger extent (Pina, Apstein et al. 2003, Karoff, Held et al. 2007).

**2.4 OBJECTIVES OF CARDIAC REHABILITATION:**

1. A significant improvement in the patient’s functional capacity,
2. Psychological adaptations to the chronic disease process,
3. A foundation for long-term behavior and lifestyle changes to favorably influence the long-term prognosis,
4. Maintenance of an independent lifestyle for as long as possible.

In general, the CR consist of phases namely inpatient, outpatient, and in the community or at home-based training phases. Patients are included in CR programs after risk stratification as per standard guidelines aiming at optimal health benefits. Vitals stabilization; initial ambulation and self-care participation are achieved during Phase I (Inpatient or Hospital-based training). It is followed by graded, usually supervised progressive exercise training as per patient’s response to initial training; this part of training (Phase II) is done as 12-week supervised outpatient training program in most centers.

Cardiac Rehabilitation is extended to Patients with coronary event after stabilization (medical/ surgical), Surgical correction of structural defect (Adult/Pediatric), Coronary angioplasty, post CABG, Asymptomatic people at risk, Geriatric group (Leon, Franklin et al. 2005). Among all these potentially candidates for CR, Post CABG forms a major proportion with modifiable risk
factors and hence ideal to be tested to assess efficacy of any intervention at large.

2.5 CORONARY ARTERY BYPASS GRAFTING (CABG):

CABG has become a standard treatment for patients with ischemic heart disease (IHD). CABG significantly improves survival, quality of life and decreases the symptoms of patients compared with Percutaneous Transluminal Coronary Angioplasty, (Eagle, Guyton et al. 1999). After CABG, Cardiac Rehabilitation programs are recommended by the World Health Organization (WHO) (Brown 1964, Fogel'son 1966).

Contraindications: For exercise training, which represents only a part of a cardiac rehabilitation programme, are the same as those for exercise testing, namely:

- Unstable angina
- Uncontrolled atrial or ventricular arrhythmia
- Uncontrolled heart failure
- Moderate to severe aortic stenosis
- High-degree heart block without pacemaker
- Recent thrombophlebitis or pulmonary embolism
- Non cardiac reasons, such as an orthopedic problem that would prohibit exercise and acute infections or inflammatory illness. Contraindications to other components of cardiac rehabilitation programmes are rare and are
essentially characterized by disruptive behaviours which may not be tolerated in a group of patients. In such cases, individual support appropriate to these patients should be considered.

2.6 COMPONENTS OF CARDIAC REHABILITATION PROGRAMME:

A cardiac rehabilitation programme includes:

1. Risk assessment and stratification
2. Medical treatment
3. Exercise capacity testing
4. Exercise training programme
5. Risk factor modification strategies
6. Psycho-social counseling
7. Vocational counseling

2.7 RISK STRATIFICATION

The present study focuses on exercise training after risk stratification which is explained as follows:

The first step-Risk stratification of cardiac rehabilitation is to rule out contraindications and prescribe suitable exercise programme for the patient. Even though exercise testing by Treadmill or Ergometer has been recommended by some guidelines, economic constraints limits it’s utility and hence clinical exercise testing is accepted as a standard method of evaluation for exercise
prescription with low intensity training (WHO/CGC Task Force)(Eagle, Guyton et al. 1999, Farin, Dudeck et al. 2007). Broadly, patients are classified as low, intermediate or high risk patients as follows:

**LOW RISK PATIENTS:**

- Uncomplicated in-hospital courses during the acute phase.
- No detectable residual ischemia or ischemia occurring at high threshold (>6 METS)
- Left ventricular ejection fraction > 50%(17)
- No complex arrhythmia’s
- Functional capacity of >6 METs.
INTERMEDIATE RISK PATIENTS:

- Myocardial ischemia at intermediate threshold, or exercise ST-segment depression below 2mm, or reversible defects during stress echocardiography or nuclear radiography.
- Left ventricular ejection fraction between 31 and 49 % or below 40% with preserved functional capacities
- No sustained ventricular arrhythmia.

HIGH RISK PATIENTS:

- Survivors of sudden cardiac arrest.
- In-hospital complications during the acute phase (cardiogenic shock, heart failure, severe arrhythmia)
- Severe coronary artery disease, marked induced myocardial ischemia with ST-segment depression higher than 2mm, or extensive ischemia occurring at low threshold (< 6 METS or <100 watts).
- Left ventricular ejection fraction below 30 % with low functional capacities.
- Decrease or failure to rise in systolic blood pressure during graded exercise testing.
- Complex ventricular arrhythmia such as sustained ventricular tachycardia at rest or during exercise. This classification has, however, some limits, as the data have only been validated in coronary heart disease patients and some
new parameters are not mentioned (such as the patency of the infarct-related coronary artery).

2.8 PHASES OF CARDIAC REHABILITATION:

PHASE I - INPATIENT REHABILITATION: Phase I rehabilitation in hospital includes vitals stabilization, graded ambulation and family education about cardiac risk factors. It guides to attain self-dependency, physical and psycho-social independence. There is a drift towards achieving early and optimal functional capacity during Phase I rehabilitation (Leon, Franklin et al. 2005).

PHASE II - OUTPATIENT REHABILITATION: Phase II rehabilitation consisting of a structured exercise training lasting six to twelve weeks after discharge, done under guidance. The duration of training is tailor made as per needs of patient/or family and the community. It consists of unsupervised and/or supervised exercise sessions, education on the disease, diet and on initiation of self-care, physical, vocational and sexual activities. The sessions are designed and conducted either individually or as group counseling as per patient’s condition.

PHASE III - LONG-TERM INTENSIVE OUTPATIENT CARDIAC REHABILITATION: Group exercise is imparted during this Phase. The subject learns to assess the changes in Cardiac responses to exercise, and to do rating of perceived exertion (RPE). The adverse effects are averted by
supervised guidance of physiotherapist periodically and gradually the exercise capacity improves. A tailor-made exercises program including mobility, stability training and aerobic exercise is designed and progressed by the Physiotherapist.

**PHASE IV: ONGOING MAINTANANCE PHASE:** The final phase of cardiac rehabilitation is a lifelong self-regulated period of training. Usually subjects with compliance in the previous phases, gain the knowledge about the cardiac diseases, modifiable risk factors, and methods to sustain the benefits of training. Furthermore, the necessary changes to the exercise/lifestyle to achieve optimal health are guided as needed.

**2.9 IMPORTANCE OF PHASE II CR**

Phase II (Outpatient/Monitored): Multifaceted outpatient rehabilitation, lasting from hospital discharge to 2–12 weeks later. Phase II CR emphasizes safe physical activity to improve conditioning with continued behavior modification aimed at smoking cessation, weight loss, healthy eating, and other factors to reduce risk against disease.

The patient’s motivation to address lifestyle changes is strongest during this phase. The emphasis is on health education and resuming normal physical activities.

Patient and Family members are educated about
- Modifiable and non-modifiable risk factors,
- Nutrition,
- Physical activity and exercise,
- Stress management,
- Psychological aspects,
- Spouse, partner and family support,
- Return to work,
- Resumption of intimate and sexual activity,
- Medication,
- Coronary disease management including investigation,
- Medical and surgical treatment,
- Cardio pulmonary resuscitation (CPR) for spouse, partner and family as well as the patient.

Before entry into the programme the patient and patient’s spouse and family should ideally have a personal interview with a designated rehabilitation specialist to tailor the programme to individual needs and set realistic goals. Tailoring the programme to the patient’s needs should empower the patient and improve adherence (Ades, Pashkow et al. 1997). A midpoint review of initial
programme goals can aid adherence by the provision of feedback and encouragement.

Rate of recovery depends on age, gender, and other health conditions. Depending upon the condition and how patients respond to rehab, they may stay in a particular phase or move back and forth among the various phases.

Phase II (Outpatient/Monitored): It emphasizes safe physical activity, and healthy life style changes to reduce risk against disease. (Wenger 1996, Friedman, Williams et al. 1997). The maximal exercise capacity achieved following CABG by an individual, which would be sustained for rest of life (Phase III) is determined during this period only and hence is a golden period to optimize the progression in exercise capacity but also habituate the lifestyle modification.

2.10 PHYSIOLOGICAL PARAMETERS:

ECHOCARDIOGRAPHY: The impact of left ventricular dysfunction on the exercise capacity of CAD patients is not clear. A study has shown the positive outcomes of CR in post-MI patients with LV dysfunction without causing serious cardiac complications (Sadeghi, Garakyaraghi et al. 2013). Hence, this study includes Ejection Fraction as one of the outcome measure.

RATE PRESSURE PRODUCT: Rate pressure product (RPP) reflects the cardiac oxygen consumption and it is an important indicator of ventricular function. The peak rate pressure product (PRPP) corresponds to the myocardial
oxygen demand and myocardial workload. So calculating RPP is an important parameter. It is indicated that one should obtain 11000-15000 as RPP and can rise up to 22000.

2.11 EXERCISE TESTING

An objective exercise testing procedure was developed by using a treadmill or bicycle ergometer to determine maximal exercise capacity. Maximal exercise testing has been extensively validated for diagnosis, prognosis and exercise prescription. Maximal exercise testing requires specialized facilities, equipment and personnel and is associated with considerable cost. However, most of the human activities are always associated with sub maximal exercise capacity level. Hence sub maximal exercise testing’s were considered to be safe and feasible for more debilitated patients or patients with low exercise capacity or high risk population for than graded maximal exercise testing. The field tests such as Six Minute Walk Test has been widely validated and used in Cardiac Rehabilitation in recent times.

REASONING OF OUTCOME MESURES USED IN THIS STUDY: In 1960’s Balke developed a simple walk test with defined period of time (Balke 1963, Guyatt, Sullivan et al. 1985) which was later modified to twelve minute walk test (Cooper 1968). When this 12 minute walk test was performed in patients with respiratory and cardiac problems, it was too exhausting (Butland,
Pang et al. 1982) and therefore a six minute walk test was developed which is easy to administer, better tolerated and more reflective of daily activities of living (Solway, Brooks et al. 2001). The six minute walk test was developed by Guyatt et al. for exercise testing before exercise prescription (Guyatt, Sullivan et al. 1985).

Lipkin has first introduced the 6MWT as a functional exercise test in 1986. Its results were highly correlated with those of the 12-minute walk test from which it was derived and with those of cycle ergometer or treadmill based exercise tests. The 6MWT was also found to be a valuable instrument to assess progression of functional exercise capacity in different clinical intervention studies.

In a cardiac rehabilitation set up while prescribing exercises, six minute walk test as originally described by Guyatt et al (Guyatt, Sullivan et al. 1985) are used for both initial assessment and document functional outcomes after completion of cardiac rehabilitation program. There are equations in six-minute walk test using which, the distance walked can be converted into a measure of functional capacity [vo2max] (Bittner, Weiner et al. 1993, Hamilton and Haennel 2000). The distance walked can be used as the marker of disease, severity, and prognosis and as the outcome measure in clinical trial testing in medical and surgical procedural therapy.
VALIDITY AND RELIABILITY OF SMWT: Usually age, gender, height, body mass determine the walk performance in adult population (Enright and Sherrill 1998, 2002). According to American association of cardiovascular and pulmonary rehabilitation (AACVPR) risk stratification most of the adults having history of sedentary life style and low physical function, determined by SF 36 questionnaire, and showed corresponding low performance in SMWT. There are several studies that have assessed the correlation between the functional capacity derived out of 6MWT and symptom limited graded exercise testing and found to be highly correlated.

There is maximum correlation in the rehabilitation equivalent value when compared to rate of perceived exertion suggesting that the 6MWT is more a sub maximal exercise test (Bautmans, Lambert et al. 2004), and hence can be considered as the exercise testing procedure in cardiac rehabilitation set up (Rasekaba, Lee et al. 2009). The reliability of the test in healthy elderly persons and patients were high (Intra Class Correlation = 0.93) and it has been established as a valid and reliable test to assess the exercise capacity of various patient groups.

The baseline 6MWT distance in (UAB) University of Alabama at Birmingham cardiac rehabilitation (Bittner, Weiner et al. 1993) program of ischemic heart disease patients in total number of n=30 was mean equivalent to 1351 feet±361 (411meter) with minimum value of 120ft (36meters) and
maximum value of 2322ft (707 meters). A British cardiac rehabilitation program reported an improvement in 6-min walk distance from 1032±249 to 1238±258 feet over 6 weeks of training (two exercise sessions per week) but did not indicate the proportion of patient’s improvement.

**CLINICAL APPLICATION:** Initially, SMWT was used as field test to monitor the outcomes of therapy specifically in pulmonary conditions; Later was used to assess the exercise tolerance in patients with low work capacity and high risk group for graded, maximal exercise testing. Thus, gradually SMWT was used in cardiac rehab programs with validation with standard testing protocols and self-reported measures (Troosters, Gosselink et al. 1999, Rasekaba, Lee et al. 2009). The 6MWT data guides the exercise prescription in cardiac Rehabilitation by making use of American College of Sports Medicine (ACSM) working equation. Distance walked by the patient: 420 meters in 6 min. Calculate walking speed: Calculate speed in m/min: 420 m/6 min = 70 m/min. Calculate metabolic value for walking without grade:

1 MET = 3.5ml/kg/min; 0.1 is the constant for converting m/min to ml/kg/min

Estimated oxygen consumption \( V_{O_2} \) Max = 3.5ml/kg/min + O2 consumed in 6MWT (in ml/kg/min)
Thus, \( V_{O_2} \text{Max} = 3.5 \text{ml/kg/min} + 70 \text{m/min} \times 0.1 = 3.5 + 7 \text{ml/kg/min} = 10.5 \text{ml/kg/min} \).

MET level achieved: \( 10.5 \text{ml/kg/min} / 3.5 = 3 \text{ METs} \).

Metabolic value can be used for exercise prescription on apparatus other than treadmill MET, metabolic equivalent.

Using the Cahalin formula \( [V_{O_2} \text{Max} = 0.006 \times 6\text{MWD (FEET)} + 3.38] \) also can be used as described by Walter Villobos et al., have concluded in their study that 6MWT is more reliable in cardiac rehabilitation and have better correlation in term of \( V_{O_2} \text{Max} \) (ACSM 2006). In their study they also concluded patients with a 6MWD of less than 360 have low level exercise capacity and those with 6MWD great than 546 have moderate to high level of exercise capacity. They also use an equation to find the predicated value for 6MWT equation \( 218 + (5.14 \times \text{HT IN CM} – 5.32 \times \text{AGE}) – (1.80 \times \text{WT} + 51.31) \). It is observed that in healthy individuals will have a predicted 6MWD of 631 ± 93 meter.

Six-minute walk test is a universally accepted field test. It is safe, simple and well tolerated by most patients, even by frail elderly. It is reliable and feasible for many patient populations including the renal patients. The six-minute walk test (SMWT) is a simple, safe, and inexpensive test that uses an exercise mode relevant to everyday activities. The SMWT is a good measure of
functional exercise ability because it is self-paced and sub maximal in nature. The SMWT is also well-accepted by patients, easily administered, and easily reproduced (Troosters, Gosselink et al. 1999, Rasekaba, Lee et al. 2009) (ACSM 2006) Recent studies indicate that Six minute walk distance predicts the mortality in different groups of patients. The SMW distance was found to be correlated with mortality prediction in patients with colon cancer and lung transplant (Martinu, Babyak et al. 2008, Moriello, Mayo et al. 2008). It is quite interesting to note that a recent study have found the prediction ability of the SMWT in patients waiting for liver transplant, which was equivalent to predictability as that of MELD (Model for End stage Liver Disease) score which is used for prioritizing patient waiting for liver transplantation (Carey, Steidley et al. 2010). Thus, the applications of SMWT extends beyond Cardiopulmonary testing and monitoring therapy response.

**LIMITATIONS:** The SMWT is a useful method for fragile, debilitated individual but may not be a suitable tool for normal subjects and sports training as it does not show a correlation with maximal exercise testing in this population. Moreover, it has value of correlation rather than exact measure of sub-maximal exercise capacity of an individual (2002, 18). However, psychological factors such as depression and cognitive impairment all have a negative effect on the timed walking distance (Reybrouck 2003). The SMWT interpretation should include consideration of vascular, pulmonary, and
musculoskeletal exercise limitations, as the mechanisms to limitation in the physical capacity might not have same physiological process and may have confounding variables also (Garin, Highland et al. 2009). The reliability in prediction of changes in VO\textsubscript{2} max among the patients awaiting cardiac transplantation still remains unestablished (Cheetham, Taylor et al. 2005). Therefore the SMWT is well established for safe clinical test for variety of patients. As its role expands to prediction of outcomes of patients requiring surgical interventions and high risk individuals, the test needs to carefully used with due precautions taking into consideration of the limitations. The normative data, effects of medications, nutritional status, and level of racial differences in patient groups needs further testing before generalization. The predictive value still needs clarification due to less number of published data in various conditions other than cardiac and pulmonary diseases and need to consider the confounding variables as SMWT could not point out the source of deficit in all patients.

The normative and comparative data in Indian population for various groups is yet to be established, which could provide more insight on the minimal standards of exercise tolerance and predictive values in those patients. Thus, SMWT could serve as a clinically useful tool facilitating efficient method of estimating an individual’s physical capacity with a functional test. The SMWT should be considered as useful complementary information about the
functional status of patients with cardiovascular or pulmonary disease, while the utility needs further testing in other groups of patients.

**QUALITY OF LIFE:** The QOL includes perception of self-worthiness in life attained by satisfaction on different aspects of life by the accomplishment of varies of roles in a daily life. Along with physical performance, the psychological and social behavior is also affected after Coronary event. The survival rate following a cardiac event has drastically increased. Most of the survivors have significant physical, psychological and social disabilities affecting their QOL. There is increasing concerns to improve the QOL, which remains the essence of rest of their life. The increase in physical and leisure activity also leads to improved psychological stability and increase their self-confidence.

The comprehensive questionnaires such as the Sickness Impact Profile (SIP), the Seattle Angina Questionnaire, WHO BREF QOL, the Short Form - 36, the Minnesota Living with Heart Failure, the Nottingham Health Profile, the McMaster Health Index Questionnaire, the Quality of Well – being Scale are used to assess QOL. (Failde and Ramos 2000, Failde, Medina et al. 2009, Agnihotri, Awasthi et al. 2010).

**BREF-QUALITY OF LIFE:** WHO QOL-BREF is developed by WHO is widely used to evaluate cardiac patients undergoing Cardiac Rehabilitation. The WHO QOL-BREF is a comprehensive, cross-culturally valid assessment of
QOL, with four domains: physical, psychological, social and environment (Agnihotri, Awasthi et al. 2010). Thus WHO BREF QOL is was taken as one of the outcome to indicate post CABG quality of life.

2.12 EXERCISE TRAINING:

The exercise training as a method of treatment was conceptualized by William Heberden, and later supported by the William Stokes scientific articles. The proceedings of American Medical Association meeting at Chicago in 1944 paved way for drifting the initial trend of prolonged bed rest towards activity based treatment following a coronary event.

Gradually the clinical usage of “armchair treatment” (Newman, Andrews et al. 1952), early mobilization and progressive activity training led to trend of developing a structured inpatient exercise regimen with low level self-care activities (Wenger 1969) evolved.

The safety of supervised exercise training for uncomplicated cardiac patients was established (Gottheiner 1968). Several trails witnessed the utility of post – coronary rehabilitation (Hellerstein 1970, Kavanagh, Shephard et al. 1974, Bassler and Scaff 1975).

The American Heart Association recommended Cardiac rehabilitation as complementary treatment to drug therapy or surgery(1981). The World Health Organization also recommends regular aerobic exercise as the vital part of a cardiac rehabilitation programme (1982).
Most Phase II exercise programs consist of three sessions per week for 12 weeks. However, the frequency and duration may be impacted by the level of cardiac risk stratification and the degree of limitation of exercise during the treadmill ECG test prior to initiation of rehabilitation. Risk stratification is used to identify patients at risk for death or reinfarction and to provide guidelines for the rehabilitative process.

**PHYSIOLOGICAL BENEFITS OF TRAINING:** Exercise brings about anatomical and physiological changes in trained muscles with increased energy storage and improved utilization rate; the oxygen utilization capacity also improves (Leon, Franklin et al. 2005).

Studies show a desirable changes due to exercise training in CAD risk factors such as decrease in total cholesterol, LDL, serum triglycerides, plasma catecholamine levels and increase in HDL-cholesterol; improved glycemic regulation and reduction in inflammatory tissue responses (Leon, Franklin et al. 2005).

The cardiac output increases as a result of improved end diastolic volume and increased force of contraction after exercise training. The regular exercises results in reduction of rate pressure product and the work of heart. The atherosclerotic plaque regression and improvement in coronary circulation noted following exercise training. Hence, subjects achieve higher exercise capacity after training.
A meta-analysis of 48 randomized trials show a reduction of 20% in all total mortality and 26% in cardiac mortality rates, with Cardiac rehabilitation including exercise training (Lavie, Thomas et al. 2009).

Cardiac rehabilitation Phase II is assuming a vital role in secondary prevention as Phase I CR is established (Levin, Perk et al. 1991, Lavie, Thomas et al. 2009). However presently in India there are only few cardiac rehabilitation center implementing Phase II training.
MEASUREMENT OF EXERCISE INTENSITY:

HEART RATE: Moderate or high intensity exercise is commonly monitored by heart rate, aiming at a specified training (or target) heart rate. The training heart rate during exercise is usually based upon a prior symptom limited exercise test.

Training heart rates for moderate to high intensity exercise is based upon measurements of individual patients’ maximal heart rates from a maximal stress test and not be based upon formulae devised for healthy adults.

DETERMINATION OF TRAINING HEART RATE FROM EXERCISE STRESS TEST: The high intensity exercise trainings based on the maximal heart rate determined by a symptom-limited maximal stress test. The high intensity exercise is about 70%–85% of the achieved maximal heart rate from a maximal stress test. Moderate exercise is in the range of 60%–75% of achieved maximal heart rate. Low intensity exercise is usually in the range of 50%–65% of the achieved maximal heart rate. Thus, there is a correlation between low, moderate and high intensities of exercise training and the percent of maximal heart rate used for training.

HEART RATE RESERVE (HRR): The other formula used to determine the training heart rate is based on “heart rate reserve” as suggested by Karvonen, training intensity (%) of the difference between resting heart rate (measured)
and the HR max. The Karvonen Formula is a mathematical formula that determines target heart rate (HR) training zone. The formula uses maximum and resting heart rate with the desired training intensity to get a target heart rate.

**Target Heart Rate** = (max HR − resting HR) × %Intensity) + resting HR

**example** ideally, resting heart rate is measured and maximum heart rate for more accurate results. If the maximum heart rate cannot be measured directly, it can be roughly estimated using the traditional formula 220 minus your age. Also, an average value of 70 bpm can be used for resting heart rate if it is not known (Karvonen and Vuorimaa 1988).

**Rating of Perceived Exertion:** Studies conducted by Borghave resulted in a scale of rates of perceived exertion. The scale ranges from “no exertion at all” or “very, very light” exertion at one end to “very, very hard” or “maximal” exertion at the other end of the scale. These rates of perceived exertion have been correlated with heart rate, presented as the percentage of the maximal heart rate determined by a symptom limited maximal exercise test.

Moreover, Chronotropic dysfunction present in many cardiac patients may result in a lower maximal heart rate, thereby permitting a higher percentage of maximal heart rate at any given workload. Further, the possible blunting of heart rate response in some patients generates a wide range of increment over resting heart rate. In addition, the different levels of exercise training and of perceived exertion may be accompanied by significant overlapping of
percentage of maximal heart rate and increment over resting heart rate. Therefore RPE is useful as adjunct to do self-monitoring of exercise intensity after initial guided training.

Based upon these correlations, it has been accepted for patients to exercise at a given rate of perceived exertion, which correlates with their advised or prescribed training heart rate. This correlation may also be applied to the increment in heart rate over the resting heart rate. Thus, it is possible for patients to monitor their own exercise levels, based either upon heart rate or rating of perceived exertion.

**FREQUENCY OF EXERCISE SESSIONS AND DURATION OF PROGRAM:** The improvement in exercise capacity gets plateau after 10 to 21 weeks (Foster, Pollock et al. 1984, Foster, Oldridge et al. 1995). Currently, the recommended frequency for supervised exercise of high or moderate intensity is three to five times weekly lasting for 12 weeks (1994, 1995, Thompson, Bowman et al. 1996, Mazzini, Stevens et al. 2008). The high intensity exercise training lasting more than half an hour carries the risk of damage to muscular-skeletal system. The risk of injury is greater if exercise training occurs more frequently than on alternate days (Pollock, Gettman et al. 1977, Pollock, Graves et al. 1994).

Supervised twice weekly group exercise programs are recommended as they also yield similar benefits to group exercise training conducted thrice a
week (Worcester, Hare et al. 1993). The twice weekly has been shown as an appropriate frequency with equivocal benefits of long programs (Stone and Arthur 2005), (Lewin, Ingleton et al. 1998), (Hedback and Perk 1987, Dressendorfer, Franklin et al. 1995). Hence 2-3 sessions in a week will be effective and 3-5 times a week sessions will be more beneficial.

**RESISTANCE TRAINING IN CARDIAC REHABILITATION:** Resistance training results in an increase in muscular strength and endurance by increasing muscle mass and or improving coordination and muscle metabolism. It minimizes loss of muscle mass and strength occurring with heart disease as well as increases the exercise and functional capacity (Cordina, O'Meagher et al. 2013).

Tailor made and graded resistance training in patients with preserved Left ventricular function is shown to be safe and effective in cardiac patients, supported by the current CR recommendations. Resistance training is found to be feasible and useful among geriatric and both genders of the population. The clinical efficiency and patient’s safety with resistance training is well established (Chicco, McCarty et al. 2006).

It is recommended to use 3 sets 8-12 repetitions of any four gross muscles. To start with one third of one Repetition Maximum (RM) (ACSM-GUIDELINES) should be used. The progression should be made up a maximum
of two thirds of one RM. The progression is maintained for two weeks and then the load of resistance is increased in a calculated stepwise manner.

**DURATION OF PROGRAM:** The 12 weeks of supervised exercise training is empirically accepted for Phase II Cardiac rehabilitation.

2.13 UNSUPERVISED CONVENTIONAL HOME BASED SELF-MONITORED EXERCISE PROGRAM.

A home exercise program is recommended for patients unable to attend hospital based. Trials have shown better outcomes with supervised training than only home based training. (DeBusk, Haskell et al. 1985, King, Haskell et al. 1991). Studies show that the exercise capacity and psychosocial outcomes achieved by patients randomly allocated to a hospital based group program than unsupervised home based training are higher. Even though home-based programs reduce the patient’s commutation time they require careful assessment before an exercise prescription.

2.14 PRESENT TREND:

Cardiac-rehabilitation programs begin to develop in the 1960s as the benefits of ambulation during prolonged hospitalization for coronary events gained recognition. In initial days, after discharge from the hospital, the process of physical reconditioning was continued at home with exercise. Currently, the Phase I (hospital stay) duration after acute coronary syndromes has now got shortened and so the de-conditioning is minima (Hellerstein 1968). The
structured exercise training and lifestyle modification leads to positive outcomes after MI. The benefits of cardiac rehabilitation and secondary prevention are broad and compelling which includes improvement in lifestyle, reduction of CVD risk factors, cost of care, and reduction in disease progression (Pashkow 1993, Newby, Eisenstein et al. 2000).


2.15 IDENTIFIED CHALLENGES OF PHASE II CARDIAC REHABILITATION:
While there is numerous benefits of Cardiac-rehabilitation, there is several challenges which include low program participation, lack of referral, poor program compliance problems, high dropouts, meager resource availability, commutation constraints to facility, lack of motivation, and patient's unwillingness to attend (Liehr, Leaverton et al. 2003).

The successful implementation of Cardiac Rehabilitation is greatly challenged by the high dropouts and poor adherence. A comprehensive data on compliance of Cardiac-rehabilitation and its influence on risk-factor modification are not available (Hahmann 2012); (Meikle, Al-Sarraf et al. 2013).
IN OUR POPULATION

The coronary artery disease is increasing with incidence due to change in lifestyle of people in India. The prevalence of the Myocardial infarction and surgical revascularisation are on increase these days. As there is ongoing development in survival rate, better and evidence based methods of Cardiac conditioning are need of the hour to attain optimal physical health and Quality of Life (Madan, Babu et al. 2014).

In the last 50 years there have been multiple CV epidemiological studies in India that have defined prevalence of CHD and stroke and identified burden of disease (Gupta, Joshi et al. 2008). A meta-analysis of these studies reported that prevalence rates have more than tripled in the Indian population (Gupta R, Gupta VP et al. 1996). Increase in CHD has historically been an urban phenomenon with a recent and rapid rise in rural populations being reported (Gupta R, Guptha S et al. 2012).

The review made by Madan, Babu et al suggests that in India there is dearth of literature and limited focus of research in this area. Nevertheless, it is interesting to observe a wide heterogeneity in various centers from across India implementing CR for patients with CVD. There fore it clearly appears that research in CR in India has to be expanded (Madan, Babu et al. 2014).

Hence, this study was taken up to find out the effects of supervised exercise training on the Functional capacity, Physical, Physiological outcomes
and Quality of Life during Phase II Cardiac Rehabilitation following CABG for Low Risk Cardiac Patients at Sri Ramachandra Medical Centre, Chennai. As a low adherence to exercises during Cardiac-rehabilitation was expected in our population, the barriers for not participating or not following exercise program during Phase II Cardiac-rehabilitation was analyzed.
CONSORT FLOW CHART

Enrollment

Block Randomized (n=114)

Excluded (n= 221)
- Not meeting inclusion criteria (n=115)
- Declined to participate (n=31)
- Other reasons (n=75)

Baseline assessment-SMWT, Physical, Physiological, QOL

STUDY GROUP
12 weeks Supervised training protocol

Allocated to intervention (n=55)
- Received allocated intervention (n=47)
- Drop Out =8

CONTROL GROUP
Standard conventional home program (unsupervised)

Allocated to intervention (n=59)
- Received allocated intervention (n=49)
- Drop Out =10

Follow-Up

Reassessment
SMWT, Physical, Physiological, QOL

Statistical analysis
Descriptive: Demographics
Paired t –test: Pre-post within group comparison
Unpaired t –test: Pre-post between group comparisons
Linear regression analysis: Multiple factors influence on outcomes