CHANGE IN PHYSICAL ACTIVITY DURING ACTIVE TREATMENT OF CARDIAC PATIENTS

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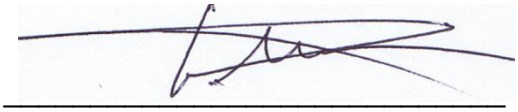
Attestation of Authorship

I hereby declare that this submission is my own work and that, to the best of my knowledge and belief, it contains no material previously published or written by another person (except where explicitly defined in the acknowledgements), nor material which to a substantial extent has been submitted for the award of any other degree or diploma of a university or other institution of higher learning.

Signature: 

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Abstract

Sedentary secular, domestic, and recreational behaviour is a major risk factor (RF) for cardiovascular disease (CVD). This study examines the quality of at-home physical activity (PA) and how it relates to physical fitness (PF) before and during 12 weeks of supervised cardiac rehabilitation (CR) in a group of medically referred cardiac patients. PA was measured with an accelerometer (ActiGraph wGT3X-BT), pre and post-CR, to determine if patient at-home PA behaviour changes during supervised CR. Cardiac patients' (n=27), haemodynamic and morphological measurements were taken. Direct measurement of the volume of oxygen consumption (VO_{2peak}) was done with respiratory gas analysis during a submaximal cycle ergometer test to determine PF. Analysis of covariance (ANCOVA) was used to assess whether exercise-induced improvement in cardiovascular and muscular capacity (CVaM-capacity) influences the relationships between stages of PF (pre vs. post-CR) and PA behaviour. Pre-CR power output and CVaM-capacity correlated moderately with overall at-home caloric expenditure per week (r=0.47 and 0.53). Calculated r^2 values indicate that power output and peak oxygen consumption contribute between 22.1% and 28.1% to the variance of weekly PA energy consumption. At-home PA behaviour (volume and intensity) changed significantly ($p \leq 0.001$) after 12 weeks of supervised CR, with moderate and vigorous PA increasing, and sedentary, and light PA decreasing. Future CR research should consider how at-home PA behaviour and other RF inter-associations affect a patient's cardiac health and CR effectiveness.

Keywords: cardiac rehabilitation, physical activity, behaviour, functional/ cardiovascular capacity, accelerometer

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List of Abbreviations

AACVPR	American Association of Cardiovascular and Pulmonary Rehabilitation
ACSM	American College of Sport Medicine
ADL	Activities of daily living
AHA	American Heart Association
ANCOVA	Analysis of covariance
BMI	Body mass index
CABG	Coronary artery bypass grafting
CAD/CHD	Coronary arterial disease/Coronary heart disease
CEP	Clinical Exercise Physiologist
CR	Cardiac rehabilitation
CVaM	Cardiovascular and muscular
CVD	Cardiovascular disease
DBP/SBP	Diastolic/Systolic blood pressure
DLW	Doubly labelled water
ECG	Electrocardiogram
EE	Energy expenditure
FITT	Frequency, Intensity, Type, Time
GXT	Graded exercise test

HRR	Heart rate reserve
IPAQ	International Physical Activity Questionnaire
MC-DHB	Mid Central – District Health Board
MET	Metabolic equivalent of task
MI	Myocardial Infarction
PA/PF	Physical activity/Physical fitness
PTCA	Percutaneous transluminal coronary angioplasty
RF	Risk factor
RM	Repetition maximum
RPE	Rating of perceived exertion
RR	Relative risk
RT	Resistance training
VO_2	Volume of oxygen consumed

Chapter 1

CR (cardiac rehabilitation) is a multifaceted tool, empirically shown to improve the physical condition, functional capacity, and quality of life of cardiac patients. Given the high correlation between cardiovascular disease (CVD) development and physical inactivity, an effective CR program must result in a self-motivated change in physical activity (PA), specifically, a positive change in at-home PA behaviour (Brubaker, 2014). Comprehensive research has been committed to the construction and validation of CR programs that produce an optimal benefit for the cardiac patient; however, gaps in knowledge still exist. There is still a need to assess the impact of a supervised CR program on the at-home PA patterns of cardiac patients.

A sedentary lifestyle is a major risk factor (RF) for CVD and the leading cause of premature death, globally (World Health Organization (WHO), 2014). The absence of PA is also a precursor to the formation and exacerbation of most other modifiable RFs. Given the correlation between a sedentary lifestyle and the development of CVD, any applied exercise intervention program must include the assessment and monitoring of baseline and successive PA levels (American College of Sports Medicine (ACSM), 2010; Fletcher et al., 1996).

The overriding goal of a CR program must be to change the behaviour that led to the patient's chronically sick state. Where PA assessment is antecedent to constructing a program, subsequent rehabilitation based on that program must incur improved PA behaviour. An immediate compliance to changing exercise and PA behaviour is desirable since an acute effective response to exercise is shown to predict future PA participation in sedentary individuals (Williams et al., 2008).

Logically there should be a correlation between the cardiovascular and muscular capacity (CVaM-capacity) of cardiac patients and the volume and quality of their PA, but it is unclear whether improved CVaM-capacity has an impact on self-motivated at-home PA patterns. This lack of clarity is surprising considering that the primary aim of a CR program is undoubtedly to improve the CVaM-capacity of cardiac patients. It is assumed that improved CVaM-capacity will positively influence the volume and intensity of PA, in the long term.

CVD patients participating in 12-week CR programs have shown positive CVaM-capacity improvement from baseline, as indicated by pre to post-MET values (Lavie, Milani, & Littman, 1993; Williams, Maresh, Esterbrooks, Harbrecht, & Sketch, 1985). These studies show an estimated peak MET value improvement of 34.0% (5.6 to 7.5 METs) and 53.0% (5.3 to 8.1 METs), respectively. One study found that CV-capacity improvements were maintainable at 1 year, post-exercise program, for peripheral vascular disease patients (Guidon & McGee, 2012); however, no research is available that associates these outcomes with at-home PA change. There seems to be a need for research that investigates the effect of CR-induced changes in CVaM-capacity on the quality of at-home PA patterns (volume and intensity) of CR patients.

Ashworth, Chad, Harrison, Reeder, and Marshall (2005) outlined the benefits of both at-home PA and supervised PA programs. The review reports that for CVD patients, a short-term (12-week) supervised exercise program produced superior improvements in cardiovascular fitness and long-term exercise compliance compared with patients who exercised at home (Ashworth et al., 2005). It is unclear what happens to the patient's at-home activity patterns

while they are engaged in the 12-week supervised program. One would expect that Ashworth et al.'s (2005) findings would indicate a change in at-home exercise behaviour. However, the envisioned outcome of improved exercise participation, as an acute response to CR initiatives, remains unproven. If there is little change of at-home PA from pre to post-CR program, but significant change in physical fitness (PF), this may indicate an abdication of responsibility for changing PA habits to the CR prescriber and a reliance on the CR program for incurring exercise health benefits. The question is whether the patient will assume responsibility for improving their at-home PA, at the conclusion of a structured CR intervention.

Consideration must be given to expediting the patient's transition from outpatient to a clinically stable, independent, physically active individual, given the short duration of regular CR programs (Giannuzzi et al., 2003). Cardiac patients will likely have minimal understanding of the rehabilitation process and will lack the ability to succinctly address adverse events occurring during rehabilitation (Giannuzzi et al., 2003). Additionally, a fully effective CR program will need to be safe, individualised, continually monitored, and adapted to the patient's response to exercise (King et al., 2005). Supervision and guidance of the patient for the duration of CR is inferred here, especially for those individuals who physically struggle due to post-event complications such as angina, low ejection fraction, heart rhythm abnormalities, and orthostatic intolerance issues. The higher the level of required supervision (extrinsic motivation), the less likely patients are to engage in PA at home. Conversely, the more autonomous the improvements patients make during the rehabilitation program, the higher the likelihood of spontaneous at-home physical

engagement (intrinsic motivation); (Teixeira, Carraca, Markland, Silva, & Ryan, 2012).

Medical supervision is advised during CR (New Zealand (NZ) Heart Foundation, 2002), and can be described as a responsibility instrumental in attaining optimal results for both the patient and program outcomes (King et al., 2005). Fokkenrood et al. (2013) investigated peripheral arterial disease patient responses to supervised compared to unsupervised, CR training. The author found statistically significant improvement in maximal treadmill walking distances for supervised compared to non-supervised exercise therapy programs at 3 months (effect size (ES)=0.69) and 6 months (ES=0.48) (Fokkenrood et al., 2013). However, this investigation did not extend to at-home PA behaviour.

There is a general acceptance that to produce a health benefit, PA needs to meet certain criteria of intensity, duration, frequency, and overall calorie expenditure. Some studies suggest a minimum caloric expenditure of 1000 kilocalories per week ($kcal.wk^{-1}$) is sufficient to produce health benefits, and an acceptable level of cardiovascular fitness (Haskell et al., 2007; Pollock et al., 1998; US Department of Health and Human Services, 1996).

The question that arises is whether supervised CR will increase at-home PA to levels that can produce health benefits and whether fitness levels influence that impact, if any. Therefore, the aims of this project are to determine: a) whether pre-rehabilitation frequency, duration, and intensity of at-home PA predict/correlate with the pre-rehabilitation CVaM-capacity of cardiac patients; and b) whether the at-home PA patterns of cardiac patients change during participation in a supervised CR program.

Chapter 2 – Literature Review

2.1 Introduction

The benefits of PA and exercise for health and fitness are well purported; however, many of the mechanisms by which these benefits are derived are still unclear. Ambiguity persists with the PA/PF relationship, specifically, where and how they fit within a CR paradigm. Do cardiac patient PF levels influence their PA patterns/habits? Can we assume a cyclic relationship between PA and PF if evidence suggests fitter patients are also more active? If the results show a high correlation between fitness and PA patterns in cardiac patients can we then also assume that the cardiac patient's PF level is a relatively accurate, although crude, reflection of PA habits? Also of interest, does attending a CR program change the patient's volitional inclination not only to be active but also to engage in higher intensity exercise?

The interrelationship between PA and PF for healthy populations has been comprehensively researched. Limited research exists that has investigated this interrelationship with cardiac patients before, during, and after CR. Additionally, is CR effective for changing risk behaviour? This review will look at the PA/PF relationship, and the recommended exercise/PA behaviour for cardiac health. The review will investigate what is known about the topic of CR, and how CR fits within the spectrum of cardiac healthcare, with some focus on existing barriers to CR implementation. CR intervention considerations are identified, and literature that has investigated CR effectiveness for improving risk behaviour (PA habits) is summarised. The CR effect on PA will include an analysis of evidence, if any, of acute self-initiated at-home change in reaction to

the rehabilitation intervention. Literature justification for the utilisation of measuring instruments and protocols is included.

2.2 The PA and PF Interrelationship for Cardiac Health and CR

PA can be defined as any bodily movement produced by skeletal muscles that results in energy expenditure (EE) (Casperson, Powell, & Christenson, 1985). PF represents the ability/capacity of the individual to perform PA (Sahn, Lockwood, & Scrimshaw, 1984; Balady et al., 2010). The benefits of PA and PF for cardiac health cannot be understated, and in a clinical setting it is known that health-related PF and PA are interrelated (Seals, Hagberg, Hurley, Ehsani, & Holloszy, 1984). Also known is the consequential improvement in PF due to continued and adapted frequency, intensity, duration, and type of PA (exercise); (Seals et al., 1984). Studies have also looked at the role PA plays in improving cardiac RFs (Fletcher et al., 1996; Magalhaes et al., 2013; Perk et al., 2012; Vuillemin et al., 2005). Most cardiac RFs respond positively to intervention with PA, making it one of the most efficient and cost-effective CVD treatment modalities. Although PA should not supersede or replace other treatment methods (lifestyle change, medication, psychosocial counselling), it is

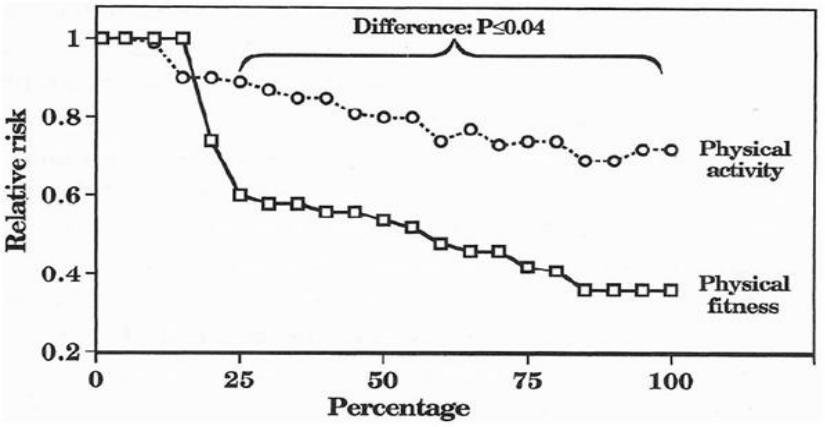

Figure 2.01. Estimated Dose-response Curve for the Relative Risk of either CHD or CVD by Sample Percentages of PA and PF (From Williams, 2001)

widely considered to be an integral aspect of cardiac health maintenance and rehabilitation.

Haskell, Montoye, and Ornstein (1985) suggest further areas of inquiry that may improve our definitive understanding of the PA/PF inter-relationship:

- Can variables of the FITT principle - exercise frequency, intensity, type, and time (duration) be manipulated, individually or conjointly, within a calculated paradigm to produce a specific outcome for the patient's cardiac health and PF?
- Considering the current general understanding of upper and lower PA thresholds (caloric expenditure required to produce a benefit), will a calculated approach for prescribing intervention based on individual thresholds for each FITT variable be more effective than simply 'doing more' for achieving greater benefit?
- Is the dose-response paradigm different for each FITT variable, to facilitate greater benefit?
- Is the current FITT paradigm, or a refined version, translatable across all population sectors? (Haskell et al., 1985).

The PA/PF interrelationship is one of the two investigation aims of this study, and only contextual aspects regarding CR and cardiac health are discussed. It is important to clarify that this investigation looks at the relationship of PA and PF as factors in the CR equation and not as compared variables More research is needed to fully understand the PA/PF interrelationship, and the interplay of their component variables, for their effect on CVD through structured CR (Fig. 2.01).

2.3 Cardiac Rehabilitation

2.3.1 CR defined. On 10 December 1948, the General Assembly of the United Nations (UN) issued a Universal Declaration of Human Rights (UDHR). The declaration confirms the rights of each person, 'to a standard of living adequate for the health and well-being of himself and of his family, including food, clothing, housing and medical care, and necessary social services' (United Nations, 2015). The World Health Organization (WHO), in line with Article 25 of the UDHR, defines rehabilitation as 'the sum of activities required to influence favourably the underlying cause of the disease'. The underlying purpose of rehabilitation is to improve "physical, mental and social conditions, so that the individual can, by their own efforts preserve or resume when lost, as normal a place as possible in the community" (WHO, 1993, p.1). Widely accepted and still relevant today, the WHO's definition of medical rehabilitation is a precursor to our current understanding of CR.

CR is a spectral process, initiated in a patient following an acute cardiac event or operation. Phases are attributed to the CR spectrum of care, with Phase 1 describing in hospital intervention (inpatient CR). Phase 2 describes the acute post-discharge (out patient) CR who is typically supervised, with Phase 3 preparing the patient for independence and Phase 4 being self-directed long-term healthy lifestyle change (NZ Heart Foundation, 2002; Scottish Intercollegiate Guidelines Network, 2002). CR cannot be regarded as an isolated form or stage of therapy and must be integrated within other secondary prevention services, of which it forms only one facet (WHO, 1993). The current study focuses on Phase 2 outpatient rehabilitation. The best practice procedure for a Phase 2 CR program involves: an initial interview

(informed consent, health history, and current mental/ physical status); and pre-program testing (muscle strength, body composition, flexibility, cardiorespiratory). Data gained from pre-CR testing assists: program construction, implementation and adaptation (exercise prescription, education, counselling); and post-program retesting (ACSM, 2010).

The characteristics of each CR program differ according to the desired outcomes and objectives sought. Given the diseased state of the patient, immediate outcomes desired for the patient include improvement of physiological functions to improve the performance of the activities of daily living (ADLs) and reduce the adverse effects of a cardiac event. An additional immediate aim of intervention programs is to control the symptoms of CVD and lower the risk of re-infarction (NZ Heart Foundation, 2002; The Centre for Medicare and Medicaid Services, 2006; Lear & Ignaszewski, 2001). Ultimately, the goal is to impede or reverse atherosclerotic progression, bolster the patient's psychological health, and instil a health-promoting lifestyle, maintained over the patient's lifetime (NZ Heart Foundation, 2002; The Centre for Medicare and Medicaid Services, 2006; Lear & Ignaszewski, 2001). Physical exercise is usually the cornerstone of a CR program. It is seen as the medium by which the outcomes and goals of CR can be achieved and maintained. Benefits are derived from the improved ability of the cardiopulmonary system to perfuse skeletal muscle and the muscle's ability to utilise it (Baechle & Earle, 2008; Marieb & Hoehn, 2010). Systemic proficiency extends to improved patient lipid profile and weight management (Lavie et al., 1993). It is widely recommended that dietary behaviour, education, pharmacological intervention, and counselling

should be addressed concurrently with exercise training (NZ Heart Foundation, 2002; Perk et al., 2012).

2.3.2 CR barriers. An initial barrier to CR participation is evident with the referral process. A prospective study investigating the CR referral rate of 906 patients with CVD indicated that only 30.0% were referred to a CR program. Specific to New Zealand, emphasis must be given to the integration of outpatient CR as a continuation of inpatient care, utilising examples, procedures and outcomes from countries further progressed in CR provision. An example is the use of an automated referral system in Canada, where results showed a 52.0% CR program enrolment rate with automatically referred, vs. 32.0% for usually referred, patients. Not only were automatically referred patients more likely to enrol ($p<0.001$), they were also referred in less time ($p<0.001$) (Grace et al., 2007). Patient-orientated factors play a major role in non-participation. Research highlights a diverse range of barriers affecting the patient's will and ability to attend CR. Intrapersonal barriers typically include: psychosocial outlook (depression, anxiety, low self-esteem, low self-efficacy) (Dunlay et al., 2009; Higginson, 2008; Rogerson, Murphy, Bird, & Morris, 2012; Grace et al., 2002); a lack of motivation (‘CR won’t work’, ‘other patients don’t attend’) (Dunlay et al., 2009; Rogerson et al., 2012; Grace et al., 2009); and health factors (cardiac condition, age, co-morbidities, pain, dyspnea, mobility/disability) (Grace et al., 2009; Higginson, 2008; Dunlay et al., 2009).

Goal setting is an important tool for achieving behavioural change in cardiac patients. The patient must be clear about the goals they want to achieve. Patients may be given to ‘fatalistic’ thoughts and a feeling of hopelessness. Strategies for dealing with negative internal impetus may include

self-empowered goal setting, consideration of changes associated with a life situation and how these changes will benefit them, and a sense of responsibility for changing in consideration of family, friends, and work colleagues (NZ Heart Foundation, 2002).

CR-provider orientated barriers also contribute to low CR participation rates. The patient is not referred when healthcare providers (doctor, cardiologist) disagree about referring, and where the provider is territorial, is unaware of, misinterprets, or is distrusting of CR programs (Grace et al., 2006; O'Connell, 2014). A lack of funding is also an issue, where there is limited if any, public support due to institutional policy and health spending cuts (Grace et al., 2006). Also, there may not be a Phase 2 CR facility in the patient's immediate location, as is the case in New Zealand, given the newness of the concept and the lack of qualified clinical exercise physiologists (CEPs).

The concept and practice of CEP is new to New Zealand, with the governing body (CEPNZ) newly established in 2012. The CEP is wholly dedicated to the chronic disease rehabilitation of outpatients (Phase II patient care). While currently other health professionals (such as nurses, physiotherapists, dieticians, psychologists) perform certain aspects of CR, the CEPs scope of practice is entirely dedicated to patient transition from inpatient care to independent self-care. There is a unique opportunity in New Zealand to structure and develop the initial phases of the CR continuum, learning from others to minimise timeline and cost.

Empirical evidence indicates a need to review the CR referral process, where currently barriers inhibit the CR attendance of two-thirds of eligible cardiac patients. New Zealand, like many other countries, lacks the

infrastructure and pathways to rehabilitate acute event cardiac outpatients. The patient may be in a debilitated state, with a pessimistic psychological outlook reflecting the disabling effects of the disease. A fear of exercise and rehabilitation may prevent CR attendance due to a lack of exercise acumen, minimal understanding of their specific CVD affliction, and a perceived incapacity to exercise, especially post-cardiac event. Theoretically, a well-structured CR program should belay the patient's fear and uncertainty of exercising by assessing for, educating and motivating the person to change at-home PA behaviour, aiming at long-term compliance. However, it is uncertain whether the patient's baseline exercise capacity is related/attributable to base activity levels, where an incorrect summation/interpretation might lessen intervention effectiveness. Currently, there is no evidence that a cardiac event affects the CVaM-capacity influence on at-home PA before CR intervention. The evidence indicates that excluding a cardiac patient from attending a CR program may affect their physiological and psychological health, quality of life, their ability to conduct normal ADLs, and ability to cease or reverse disease progression (Dunlay, et al., 2009; Marchionni, et al., 2002). While it is presumed that CR-initiated lifestyle change (at-home PA patterns/habits) can positively affect the patient's CVD condition, there is no clear evidence that a structured CR program will modify their at-home exercise behaviour.

2.3.3 CR: Recommended PA/exercises for cardiac health. Large population studies that investigated long-term behavioural trends (PA-patterns) prior to the development of coronary heart disease (CHD) showed a linear dose-response relationship between PA and risk of disease development (Eaton, 1992; Eaton, 1992a) Dose requirements to elicit CHD health benefits,

assessed in numerous studies, suggest a lower threshold for the caloric expenditure of between ~150 to ~200 kilocalories per day (kcal.d^{-1}), with greater expenditure eliciting greater benefit to an upper threshold of 3500 kcal.wk^{-1}, beyond which additional benefits are negligible (Eaton, 1992). Eaton's (1992) analysis of epidemiological PA-studies highlights a large difference in the relative risk of CHD when considering total PA. Total PA, inclusive of leisure and secular activity, was compared with recreational and secular activity as individual variables. The average CHD risk assessment for total activity (RR=1.33) compared favourably to individual activity variables (RR=2.15). This outcome suggests that total PA measure provides a more accurate assessment of risk, and reinforces the statement that volume of activity is inversely correlated with risk.

Investigations that assessed the amount of caloric expenditure performed during a CR program, per session, day and week, highlighted the inadequacy of CR programs for achieving recommended caloric expenditure. The guidelines suggest at least 30 minutes of moderate intensity (3.0 to 5.9 METs) exercise 5 days per week, or at least 20 minutes of high intensity (>6.0 METs) activity for three weekdays, totalling 450 to 750 MET.min.wk^{-1} (1000 to 2000 kcal.wk^{-1}) (Haskell et al., 2007; U.S. Department of Health and Human Services, 2008). Hambrecht et al. (1993) suggest that a weekly caloric expenditure of less than 1000 kcal.wk^{-1} is associated with coronary disease progression. The study also suggests a higher caloric expenditure of 1400 to 1500 kcal.wk^{-1} is necessary to improve cardiorespiratory fitness and halt disease progression, and that a caloric expenditure of ≥2200 kcal.wk^{-1} is associated with disease regression (Hambrecht et al., 1993). As an implication,

the recommended caloric expenditure value of 1000 kcal.wk^{-1} could potentially have a negative impact on the patient's long-term cardiac health; however, to the best of my knowledge no follow-up study has confirmed the results of Hambrecht et al.'s (1993) study outcomes, using a randomised, clinically controlled study design.

Studies that investigated at-home PA during CR showed sufficient caloric expenditure (>1500 kcal.wk^{-1}) in total when combining both CR and at-home PA (Ayabe et al., 2004; Schairer, Keteyian, Ehrman, Brawner, & Berkebile, 2003). Patients undergoing CR should be encouraged to perform additional exercise and develop a physically active lifestyle for both CR training days and non-training days (Ayabe et al., 2004). Results from case studies of men who recently underwent coronary artery bypass grafting (CABG) showed that performing additional PA during a CR program may lead to improved cardiac health (Sato, Makita, & Majima, 2005). Consideration of alternative training programs that maximise caloric expenditure is recommended, with a focus on incorporating caloric expenditure as an integral component of exercise prescription to achieve maximal health benefits (Savage, Brochu, Scott, & Ades, 2000; Schairer et al., 1998; Schairer et al., 2003). Best practice CR guidelines (ACSM, 2013; NZ Heart Foundation, 2002) emphasise the importance of physical exercise as part of recovery after a cardiac event, due to the demonstrable effect of CR on mortality, morbidity, recurrent events, and hospital readmissions. Guidelines also state that a structured approach (with three distinct phases), needs to be followed when introducing patients to physical exercise. Exercise criterion for intensity, duration, frequency, and type of

exercise needs to be tailored to the patient's ability in each phase (ACSM, 2013).

The underpinning theory of the Health-Belief Model is that patients will exhibit healthy behaviour if they value their health and expect their behaviour to impact positively on their illness. The initiation in and adherence to health behaviours have, according to this theory, four constructs including the perceived seriousness of the health problem, the perceived benefits of and barriers to taking action, the perceived risks, and cues to action. These aspects interact, according to the model, with specific demographics such as socioeconomic status, age, and gender (Champion & Skinner, 2008). The Transtheoretical Model of Behaviour Change states that change normally involves five distinct phases, namely; pre-contemplation, contemplation, preparation, action, and maintenance (Prochaska, Redding, & Evers, 2008).

It is evident from the two models (Health-Belief Model and the Transtheoretical Model) that a health scare such as a cardiac event, and random health-related information (why the need to exercise), are not enough to produce lifestyle change. The cardiac patient who has survived an acute event, or suffers from chronic heart disease needs particular attention to restore quality of life, improve CVaM-capacity and lead a productive life. Cardiac patients need to develop safe and effective exercise habits, with individually tailored and specific exercise and lifestyle education help to overcome fears, and an understanding of the importance of exercise (NZ Heart Foundation, 2002). This study is, consequently, designed around the following five general premises:

1. Exercise is essential for optimal recovery after a coronary arterial disease (CAD) event (ACSM, 2013; NZ Heart Foundation, 2002).

2. Exercise needs to meet certain criteria to be effective and safe (ACSM, 2013).

3. Best practice CR guidelines suggest a structured process of at least three phases, which will introduce the patient first to therapeutic exercise in a supervised exercise environment, and then guide them through support, monitoring and education, aiming at adopting regular exercise as part of their lifestyle (NZ Heart Foundation, 2002).

4. The optimal goal of CR is to impact on the aspects that caused the problem in the first place, and that involves helping the client to adopt a health-promoting lifestyle, which should include regular physical exercise/ activity (NZ Heart Foundation, 2002).

5. Personal and external factors like knowledge, fear, income, perceived seriousness of the cardiac condition, exercise outcome expectancies, and support systems will influence the successful adoption of long-term exercise behaviour. The adoption of exercise behaviour is therefore not an automatic process after a cardiac event (Balady et al., 2007; NZ Heart Foundation, 2002). Carefully planned and structured processes are needed to guide cardiac patients to regular, safe and effective exercise habits.

2.3.4 CR: Intervention program considerations. Although there is no one typical CR program, there is a general agreement about the basic structure of a viable program (NZ Heart Foundation, 2002; Balady et al., 2007; Giannuzzi et al., 2003; Lear & Ignaszewski, 2001; Mampuya, 2012). The spectrum of health care for the cardiac patient starts as an in-patient, continuing through to

self-reliance and independence from structured health care programs. According to Giannuzzi et al. (2003) the program structure should consider the requirements and the demographics of the participant, including social circumstances and available resources. To be considered CR, a program must address multiple issues related to the risk of disease progression where exercise alone cannot be considered CR (Balady et al., 1994). CR core components include: patient assessment (baseline and follow-up), exercise training, counselling (nutrition, stress, PA and vocational), and RF/ psychosocial intervention (Balady et al., 1994; Balady et al., 2007; Giannuzzi et al., 2003; Lear & Ignaszewski, 2001; Mampuya, 2012; NZ Heart Foundation, 2002; Perk et al., 2012). The long-term aim of CR is for the patient to have modified the risk behaviour that promoted CVD progression and be able to maintain that new 'behaviour' independently.

It is hard to outline an optimal CR program format given the differences in structure with regard to aspects of screening and assessment protocols, the timing and duration of each program, and the exercise/ intervention regimes in use at various well-known CR centres across the globe. There is limited understanding of what CR program structure works best and what the optimal period and duration of CR should be if the aim is to change the patient's PA habits (NZ Heart Foundation, 2002). Data shows mixed results for studies that investigated cardiac patient PA habits post-CR intervention. Study results that reported a significant improvement of PA habits (Giannuzzi et al., 2003; Janssen, DeGucht, van Exel, & Maes, 2013) contrast with studies that showed a substantial decline in PA habits from baseline (Lear et al., 2003; Oerkild et al., 2010). Interventions applied to the experimental groups that significantly

improved PA included supervised exercise, counselling, and group/social support.

The response effectiveness of CR on PA behaviour is still uncertain. Comparative studies have produced contradictory results, making identification of an effective intervention difficult. Ornish et al. (1998) investigated the effects of an intensive lifestyle intervention (vegetarian diet, exercise, stress management, psychosocial support) on CR participant CHD. Patients with proven moderate to severe atherosclerosis participated in the randomised 5-year trial (Ornish et al., 1998). Results showed an average stenosis diameter decrease for the intervention group compared to an increase in the usual care (control) group at year 1, with greater atherosclerotic regression occurring at year 5 (Ornish et al., 1998). Data also points to the control group having double the amount of cardiac events (myocardial infarction (MI), percutaneous transluminal coronary angioplasty (PTCA), CABG, hospitalisation, and death), during the 5 years of follow-up. Haskell et al. (1994) similarly looked at the effects of intensive risk reduction involving lifestyle change in patients with atherosclerosis. Contrary to Ornish et al. (1998), their angiography data showed atherosclerotic progression in both the intervention and control groups, although the rate of progression was significantly slower with the intervention group (Haskell et al., 1994). They also reported significantly less cardiac event hospitalisations (n=45 vs. n=25; p=0.05) with the intervention group compared to the control group over a 4-year follow-up period (Haskell et al., 1994). The Giannuzzi et al. (2003) investigation of long-term (3-year) multifactorial intervention showed improvement in multiple outcomes. They found a significant reduction in CV mortality, higher MI survival, and reduced incidents

of stroke. A similar investigation by Oldridge, Guyatt, Fischer, and Rimm (1988) showed comparable results, highlighting greater risk reduction for longer duration investigations, with statistical significance only reported in studies that lasted at least 3 years. Until standardisation of intervention methods is seen, CR study results will only apply to identical clinical intervention scenarios.

Data does not definitively prove CR effectiveness for improving patient PA habits, due to mixed outcomes and low participant numbers in most randomised trials (Hughes, Mutrie, & Macintyre, 2007; Oerkild et al., 2011; Pinto et al., 2011). The strength of evidence for the effectiveness of structured CR (centre-based) vs. no intervention, short term and long term, highlights the disparity mentioned above (Ter Hoeve et al., 2015). Additionally, the duration of intervention seems to be inconsequential to acute CR effect where (a) limited, (b) no, and (c) conflicting evidence was found for short (1-3 months), medium (4-11 months), and long duration (>12 months) interventions, respectively (Ter Hoeve et al., 2015). The low participation numbers of women and the elderly (≥65 years) suggest results may not apply to these and other excluded subgroups. Is CR more effective for one subgroup/population compared to another? A more robust investigation is needed that specifically looks at a program design that will facilitate longer maintenance of desired behaviour and improved PA (caloric expenditure). An understanding of how core components of a CR program contribute, in tandem or in isolation, towards changing PA habits will facilitate the design of an effective intervention.

2.3.5 CR: Changing PA patterns/habits. The American Heart Association (AHA) and the American Association of Cardiovascular and Pulmonary Rehabilitation (AACVPR) outline the core components of CR. A

specific goal of CR is to reduce cardiovascular risk through lifestyle change by promoting an active life, and the continual compliance of this behavioural change (Balady et al., 2000). An investigation of the CR core components outlines a detailed strategy for the promotion of exercise through a structured counselling program. The study emphasises the determination of current at-home PA patterns, the identification of barriers, and the availability of the social support required for making a change (Balady et al., 2007). The counselling process should start at the initial interview, continuing through the CR program, aiming to educate the patient on how to exercise safely while accumulating at least 30 minutes of exercise per day, most days of the week. PA should be promoted as a lifestyle choice, avoiding calorie counting and rigid exercise regimens for patients unaccustomed or disinclined to do so. To this end, education on how to incorporate more PA into daily activities (such as taking the stairs instead of the lift, walking to the shop instead of driving, being more energetic with housework), will help to increase routine at-home PA (Balady et al., 2007).

As discussed previously, a review of studies investigating if CR leads to a change in PA habits showed conflicting results. The Ter Hoeve et al. (2015) investigation to determine if CR after an acute cardiac syndrome leads to changes in PA habits found ‘limited evidence’ that centre-based CR, and ‘no evidence’ that home-based CR, changes exercise behaviour. The review concluded that there was ‘no evidence’ that program type and/or program duration alter the long-term PA habits of cardiac patients (Ter Hoeve et al., 2015). The studies reviewed lacked congruence for CR program design, study aims, and variables measured, which limited the commonality and comparison

of data. In the United Kingdom, a multi-CR centre investigation assessed the effectiveness of a comprehensive CR program for changing PA patterns/habits. Significantly fewer patients in the rehabilitation group were exercising (expending >100 $kcal.d^{-1}$), compared to the control group, after a 12-month follow-up (West, Jones, & Henderson, 2012). A second study, investigating the impact of CR program duration and contact frequency on exercise habit, did show improvements in daily PA over time (2-year follow-up) (Reid et al., 2005). Reid et al. (2005) also assessed the benefits of extending a CR program (33 sessions) over a 12-month period compared with a 12-week program. No greater benefit was seen for changing the exercise behaviour of cardiac patients by extending the supervised training time or period, suggesting that continued contact may not be a factor in predicting long-term exercise/PA adherence post-CR program.

Studies that did show a significant effect on the exercise/PA adherence of cardiac patients (comparing intervention with usual care groups) used comparatively similar exercise intervention strategies, although follow-up and lifestyle intervention procedures differed (Arrigo, Brunner-LaRocca, Lefkovits, Pfisterer, & Hoffman, 2008; Janssen, De Gucht, van Exel, & Maes, 2012; Pinto et al., 2011; Giannuzzi et al., 2008). Applied interventions ranged from comprehensive training sessions consisting of supervised aerobic exercise, lifestyle and RF counselling with one-to-one support, through to patients receiving only telephone calls and reading material. The duration of investigation ranged from 6 months to several years' post-intervention follow-up. However, some studies that found little to no effect and a non-significant difference in exercise/PA behaviour also used similar care strategies (Lear et al., 2003,

Mildestvedt, Meland, & Eide, 2008; Moore et al., 2006). Of note, data suggests that CR-induced PA and functional capacity improvement peaks at 3 months, where beyond that there is no greater improvement (Ter Hoeve, et al., 2015). In summary, research underlines the lack of clear evidence that structured CR is adequate to improve and maintain PA behaviour, and reinforces the difficulty of disseminating, developing and applying effective CR interventions that positively affect behavioural change.

The desired outcome for cardiac patients who have completed outpatient (Phase 2) CR is to maintain the level (volume and intensity) of PA achieved during CR (Giannuzzi et al., 2003; Lear & Ignaszewski, 2001). Maintaining at-home PA post-CR is necessary to prevent cardiac event recurrence, rehospitalisation, and death from cardiac causes (Giannuzzi et al., 2003). This study defines at-home PA as self-motivated activity independent of external impetus and direction. Aside from looking at the caloric expenditure of a cardiac patient during CR attendance, this study also sought to identify whether the CR program has an immediate effect on PA behaviour. How successful is the CR program for producing an acute change in at-home PA volume and intensity? The disparity of intent and purpose within the studies reviewed makes finding successful interventions that improved PA habits difficult. Balady et al. (1994) recommend the following strategies for improving CR-induced effect on PA habits:

- convenient patient scheduling;
- individualised exercise prescription with periodic follow-up;
- pre/post-assessment reports (to the patient and referring physician);
- effective and varied exercise regimens;

- group camaraderie; and a
- focus on the patients whose medical and social profiles predict noncompliance (Balady et al., 1994).

2.4 Validity of Study Measurements

2.4.1 CVaM-capacity/PF considerations for CR. Physiological function is a reflection of a person's exercise ability and has a direct correlation with cardiorespiratory fitness/CVaM-capacity (McArdle, Katch, & Katch, 2010). PF testing measures the ability of the body, in particular the cardiorespiratory system, to maintain or regulate internal homoeostasis to near resting values when performing large muscle exercises and the patient's ability to recover quickly from exercise (Sahn et al., 1984). An indication of low CV-capacity is categorised as an independent risk factor for cardiovascular mortality (Williams, 2001). Care must be taken when deciding the structure of a CVaM-capacity test. Patients entering a CR program will have diagnosed CVD, and will typically be elderly given the chronic nature of the disease. No cardiac patient with relative contraindications for exercise should be exercise tested before being cleared by a physician, and those who present with absolute contraindications should not be subjected to graded exercise testing (GXT) at all (ACSM, 2010). A maximal test will present inherent dangers for the CR patient. Safer, submaximal test protocols are recommended for non-diagnostic pre-exercise testing where the primary aim is to prescribe a safe and effective exercise program. Additionally, a maximal test will require a clinical setting and supervision by a qualified and competent medical practitioner.

A summary of currently reviewed articles identifies the 'exercise stress test' as the predominant measurement tool of participant CV-capacity.

Symptom-limited GXT was employed by most studies, with few studies using alternative protocols (Maximal GXT, 6-minute walk test), and subjective assessment (SF-36 Physical Function Domain).

2.4.1.1 Cardiorespiratory fitness. The gold standard for measuring cardiorespiratory fitness is a maximal exercise test and ventilator gas exchange measurement (ACSM, 2010). The submaximal exercise test and ventilator gas exchange measurement, while costly and equipment reliant, provides a safe alternative, and achieves sufficient data for evaluating the patient's health-related PF (ACSM, 2010). Data are skewed due to the differing heart rate (HR) vs. oxygen consumption relationships for maximal vs. submaximal exercise; however, the error is usually small (Sahn et al., 1984). To limit further error, measurements should be taken during work, not in recovery, and work must be measurable but mechanically easy to maintain. Haemodynamic measurement should be taken during a steady state HR (< 5 bpm difference between the ends of stage minute-to-minute HR values). The work rate should not be too high where motivation may influence output, nor should it be too low that psychological factors can affect physiological function (Sahn et al., 1984). Information regarding the number of test protocols available that relate to different data requirements, and a comprehensive, peer-reviewed overview of cardiorespiratory testing, is found elsewhere (Balady et al., 2010).

2.4.1.2 Resistance training. Resistance training (RT) is suitable for CR, but the patient's condition, age and initial ability must be considered according to the ACSM (2010). Special consideration should also be given to patients who have a condition that affects PF, such as fibromyalgia or Crohn's disease. Phase II CR may be the patient's first introduction to strength training since a

short hospital stay may only allow for early mobilization and self care training, and where training may be contraindicated for some cardiac inpatients (Mampuya, 2012; Bjarnason-Wehrensa et al., 2004). Post-cardiac event CVaM-capacity may have diminished due to prolonged bed stay or corticoid therapy, compounded by pre-existing age-related muscle atrophy and habitual physical inactivity (Bjarnason-Wehrensa et al., 2004). Commencement of RT (in research studies normally) will have considered patient recovery and the continued presence of any relative contraindications, with an initial emphasis on muscular endurance (Wise & Patrick, 2011). The level of resistance should be gradually increased in line with patient adaptation to the workload and may mean starting the patient with movement only (body/limb weighted resistance against gravity), incorporating the FITT principle for resistance loading (Bjarnason-Wehrensa et al., 2004; Wise & Patrick, 2011).

Structured RT should be part of CR intervention to produce a beneficial training effect. Benefits will include improved muscle strength and endurance, muscle hypertrophy, coordination, and bone density (Bjarnason-Wehrensa et al., 2004). The effect of these benefits may incur relative improvement for functional independence and productivity, in turn improving the psychosocial outlook, quality of life, depression, fatigue, and other components of health that assist and mark cardiac recovery (Wise & Patrick, 2011). While RT is acknowledged as an important part of CR, aerobic training promotes a greater benefit for CV-capacity and CVD RFs (Wise & Patrick, 2011). A summary of CR investigations reflected a greater emphasis on aerobic assessment and training, where studies predominantly measured caloric expenditure, percentage (%) of HR max, maximum or peak volume of oxygen consumed ($VO2_{max/peak}$), METs,

and intensity, frequency and duration of exercise. While it is assumed that these measures represent the entire CR program exercise regime, the lack of RT instruction/program construction methodology makes it difficult to extrapolate proper loading for individualised intervention. Additionally, it is hard to recommend RT exercise when the effect/stress of the exercise will be different for each patient. This difficulty is especially relevant for high-risk cardiac patients who present with differing CVD afflictions of differing severity and with different co-conditions. It appears that only investigations that studied RT as an outcome measure and PA guideline articles provided sufficient RT instruction to enable the construction of an RT program unique to the individual patient. RT recommendations for loading, repetitions, exercise selection, exercise order, rest, progression, and exercise prescription for muscular flexibility are comprehensively covered in other texts (Ratamess et al., 2009; Pollock et al., 1998; Bjarnason-Wehrensa et al., 2004; Wise & Patrick, 2011).

2.4.2 Measurement of at-home PA. Measuring PA is important for determining the effectiveness of an intervention program designed to improve PA. Various PA questionnaires have been developed and tested for validity and reliability over the years (Helmerhorst et al., 2012; Scott et al., 2013). The majority correlate relatively poorly (r=0.27-0.56) with measures of cardiovascular fitness (Williams, 2001; Warren et al., 2010). Most of these questionnaires are absolute scales that calibrate the intensity of activity based on effort required by healthy, young to middle-aged adults. The International Physical Activity Questionnaire (IPAQ), generally considered the gold-standard measuring tool, for instance, express PA in absolute terms as MET minutes per week. The IPAQ calculates MET minutes per week by multiplying fixed MET-values for walking (3.3 MET), moderate (4.0 MET) and vigorous activity (8.0

MET) with minutes (duration), and days (frequency) of activity. This process ignores the fact that relative intensity of effort required for the same activity changes as one migrates across the PF spectrum. The consequence is that the IPAQ adjusts negatively for speed. An unconditioned person can obtain a higher IPAQ score because he/she perceives an activity to be hard and takes longer to complete a set distance. For example a person running 2 km, 3 times per week in 6 minutes (3 minute per kilometre pace) will get a lower IPAQ activity score than a person who walks 6 km daily in 60 minutes (10 minutes per kilometre pace). In terms of impact on cardiovascular fitness the 3 minute per kilometre pace will undoubtedly produce a superior result even though the run is performed 3 times per week. Helmerhorst et al., (2012) did a systematic review of the reliability and objective criterion-related validity of PA questionnaires and they concluded that their validity was moderate at best. They emphasise the importance of an accurate assessment of intensity levels as part of improving the validity of PA questionnaires.

Current knowledge of how the patient's health condition affects PA behaviour, and the level of PF, before and after rehabilitation, seems to be at a rudimentary level. In addition, certain areas of inquiry in the current study have yet to be investigated empirically. Intrinsic to understanding the underlying contribution of physical activity/inactivity and PF to a patient's CVD state is the requirement for valid and reliable data (Warren et al., 2010). An explanation of some of the more recent PA measurement approaches would consequently contribute towards understanding aligned knowledge and the repeatability of current study protocols.

2.4.2.1 Accelerometers. Subjective methods for recounting PA behaviour have been estimated to produce error margins between ~30.0% and ~60.0% (Ward, Evenson, Vaughn, & Rodgers, 2005; Maddison et al., 2007). To minimise measurement margins of error, objective methods are preferred. Given the many instruments available to the researcher, consideration must be given to the appropriateness for and purpose of the study, environment of use, and the ability to understand and analyse the data achieved. The type, level, and amount of information required will also impact on choice, which may be further affected by the requirement to wear multiple instruments and various integral devices (HR monitors, global positioning). Finally, the device chosen must be proven as a valid and reliable instrument.

The accelerometer is presented as a viable option for measuring PA. The accelerometer is desirable over pedometers and step counters due to the 'information-rich' data produced. Information describing the concept and the technology of accelerometers can be found elsewhere (Chen & Basset, 2005). Newer accelerometer models are also fully integrated with HR monitoring and position locating devices, allowing a more detailed analysis of PA patterns. Combined with processing software, the accelerometry data can be sorted and analysed according to user requirements (Chen & Basset, 2005). Multiplanar movement can be measured as such with multi-axial devices, giving a 3D perspective of movement as a unit of acceleration.

2.4.2.1.1 Accelerometer wear site. The trunk location is the most favoured place for accelerometer wear. Additionally, little is known about alternate wear sites (such as the wrist, ankle, and around the neck) and their output interpretability compared to gold standard calorimetry (Ward et al.,

2005). Boerema, Velsen, Schaake, Tonis, and Hermens (2014) have shown that wearing the accelerometer on the hip at the optimal position achieves the most reliable and least variable data output. Wear instruction to the participant should include ensuring the device is firmly attached to the body using an elastic belt or clips fitted as tightly as possible. The device may be worn over or under clothing, to improve wearer comfort, and if free movement (arm swing) is hampered, the device may be worn slightly forward at the hip where movement is unhindered (Boerema et al., 2014). Once the participant is comfortable with the instrument placement site, the wearing site during waking hours will not change for the duration of the assessment.

2.4.2.1.2 Number of days monitored. Given that the accelerometers are worn continuously, defining the amount of wear time (hours) that constitutes a valid day of monitoring is not necessary. However, this does not preclude the recording of spurious data that may affect hours of monitoring, resulting in unreliable and invalid data. Empirically, there is little consensus for defining the minimum hours of wear that constitute a valid day. Epidemiological studies utilising accelerometry as part of their data collection define a valid day as a day containing at least 10 valid hours. A valid hour is defined as an hour that does not include a string of 30 or more zero counts using a 60-second epoch (equivalent to 30 minutes) (Troiano et al., 2008; Matthews, 2005; Buman et al., 2010; Kerr et al., 2013). Cut-off timings indicating a valid hour and day will only be required if there is a need to define data validity per day (Evenson & Terry, 2009). The number of days monitored is dependent on the setting and purpose of the study, the population to be assessed and the availability of resources (accelerometers and accessories).

PA objective measurement negates some self-reporting errors; however, the propensity for producing error still exists. Most PA characteristics can be measured by accelerometry; however, not all information is captured. Accelerometers cannot determine the type of activity being performed and are limited in determining activities that do not involve the movement of the wearing site, such as an accelerometer worn at the hip while cycling on a static ergo cycle or certain stationary resistance exercises (Matthews, 2005). Accelerometry also involves a cost for the accelerometer devices, related software, servicing and appropriate ancillaries that may be inhibitive for many research projects. Gaps in knowledge concerning validation, statistical data analysis, optimal wear site and duration, calibration for specific populations, and the integration of current and emerging technologies need to be addressed (Troiano, 2005).

2.4.2.2 The International Physical Activity Questionnaire. Some questionnaires are available that measure PA. The IPAQ is considered a valid instrument for assessing multiple domains of PA and is used by multiple countries to collect subjective PA data (Craig et al., 2003). The suitability of the IPAQ for this study is correlative, as multiple domain PA questionnaires are shown to demonstrate a higher relationship to objective total PA measurement compared to questionnaires that only assess leisure and structured PA (Hagstromer, Oja, & Sjostrom, 2005). Of note is the validation of the IPAQ vs. the DLW method for measuring caloric expenditure. DLW technical information and protocols describing the process have been published elsewhere (Doubly-labelled Water Resource Centre, (n.d.); Maddison et al., 2007).

2.4.2.3 Logbook record. Another method of self-reporting caloric expenditure is the use of logbooks to record PA patterns. Although this approach may negate the requirement to recall, bias still exists with subject interpretation of recording requirements, the desire to record activities (participant burden, lack of motivation) and self-image bias. Despite these drawbacks, the logbook has been shown as a valid instrument for PA pattern measurement. Hagstromer et al. (2005) showed a significant correlation between 7 days of logged activity and the IPAQ. Calculated as MET.hr.day^{-1}, the correlation coefficient showed a p-value of 0.67 (P <0.001) which was slightly improved with the exclusion of outlying data (p=0.77, P <0.001). The domain specific comparison showed correlation between the IPAQ and logbook for PA at work (15.3 (MET.hr.day^{-1}) SD (30.1) vs. 16.5 (4.2)), leisure time PA (14.5 (12.8) vs. 15.4 (19.8)), and sedentary behaviour (sitting) (52.0 (16.0) vs. 44.9 (15.5)), respectively, although the PA during transport (5.1 (4.2) vs. 15.8 (14.3)) and PA at home (15.2 (12.6) vs. 7.4 (11.6)) showed a more divergent relationship (Hagstromer et al., 2005). One study looking at whether PA logbooks influence the validity of 7-day recall with PA questionnaires concluded no apparent influence to either IPAQ long or short-form validity estimates, suggesting better accuracy with recall if the log had a similar structure to the IPAQ (Timperio, Salmon, Rosenburg, & Bull, 2004). To the best of this researcher's knowledge, no data is available that directly validates PA logbooks with calorimetry method.

2.5 Summary

There is general agreement about the purveyance of CR. Studies analysed here show agreement for the need and the importance of measuring

PA and PF outcomes after CR. However, many studies do not outline method and program structure adequately, impeding valid comparison. Many facets of CR have been comprehensively researched; however, gaps in knowledge remain. The aims of this study (whether at-home PA correlates with pre-rehabilitation PF, and whether at-home PA patterns change during CR) sought to address an identified gap.

An important goal of CR is to modify the lifestyle habits of cardiac patients, specifically those habits that have negatively affected patient health, in this case physical inactivity or a predominantly sedentary existence. The question that seems to be inadequately addressed in scientific studies is whether the patient learns how to change their lifestyle (at-home PA patterns), over the course of a supervised CR program. No research was found that addresses this issue directly. Also, to approach this question, it was important to provide a reference point for change in the context of a CR program. Using PF measurement, encompassing multiple physiological aspects was viable; however, there was limited data that correlated or compared pre-CR PF with pre-CR at-home PA patterns. Given the importance of PA and PF regarding health and mortality, the current study aims to contribute to understanding the effectiveness of CR programs as a tool to generate PA behaviour change.

That physical exercise and CR have a positive effect on the RF profile, disease progression, morbidity, and/or mortality of cardiac patients seems to be well established. Owing to the multifactorial nature of CVD and the design of these studies, it is hard to proclaim an optimal CR strategy if the aim is to produce long-term PA behaviour change. Review articles and meta-analyses summarised in this chapter had pooled large participant numbers. However, the

randomised trials reviewed were small and used dissimilar interventions. Significant results were achieved for long-term (≥3 year) interventions regarding cardiorespiratory fitness and in some cases long-term changes in PA habit; however, this was at a financial cost that is outside the reach of many CR centres and patients.

Chapter 3 – Method

3.1 Participants

Patients referred by the Mid Central District Health Board (MC-DHB), Cardiology Unit, Palmerston North to the U-Kinetics Wellness Clinic for 12 weeks of exercise rehabilitation participated in this study. U-Kinetics is an MC-DHB funded physical exercise rehabilitation program located at the Universal College of Learning, Palmerston North. Data of the medically referred cardiac patients who were on an outpatient rehabilitation waiting list, and who were assessed and inducted into the U-Kinetics CR program, was analysed in this study.

3.2 Entry Criteria

The goal of CR is to restore the patient to an active and productive life. Further to improved functionality, rehabilitation may slow or inhibit disease progression and reduce the need for further medical and surgical intervention. There is general agreement between medical associations, societies, and foundations that there is no presupposed reason to inhibit a cardiac patient from participating in CR (Thompson et al., 2003). Exclusions occur of necessity, in circumstances where the cardiac patient is medically unstable, with a life-threatening condition that contraindicates CR (Thomas et al., 2010).

The NZ Heart Foundation (2002) recommends CR for CVD patients with acute coronary syndrome (acute MI, with stable angina, and following PTCA, with or without stent implantation), CABG, and valvular heart disease (surgery). The US Department of Health & Human Service, Centre for Medicare &

Medicaid Services suggests the following timeline for the provision of outpatient CR:

- patients within 12 months of an acute MI;
- patients having had CABG surgery - within 6 months of the procedure;
- patients with current stable angina pectoris. A pre-entry stress test which shows exercise-induced ischemia (a junction depression of 2 mm or more with associated slowly rising ST segment, or 1 mm horizontal or down-sloping ST-segment depression or by imaging studies) - within 6 months of starting CR;
- patients having had a heart valve repair/replacement - within 6 months of surgery;
- patients having had PTCA - within 6 months of the procedure; and
- patients having had a heart or heart-lung transplant - within 1 year of the surgery (Centre for Medicare & Medicaid Services, 2010).

The decision for referral to the U-Kinetics CR program is made offsite by a relevant physician, cardiac specialist physician or nurse practitioner as approved by the MC-DHB. Given that the MC-DHB is the CR funding authority, entry criteria into the U-Kinetics CR program is at their discretion. However, the research team determined acceptance of the patients onto this research project. The standard U-Kinetics CR program entry criteria of a stable exercise response applied as a first step entry condition. The following additional criteria apply:

- documented history of diagnosed MI/ heart disease;

- patients having had CABG surgery;
- patients with current stable angina;
- patients having had PTCA or stent insertion; and
- patients with no knee, lower back, or other musculoskeletal limitations that inhibited/prevented their ability to exercise safely at home.

3.3 Sample Size

A power analysis using a correlation (bivariate normal) model for the first aim indicated that a sample size of 45 participants would enable the detection of a correlation coefficient of at least 0.4 (alpha=0.05, power=0.80) between the PA and CVaM-capacity outcomes. Power analysis for the second aim, using the paired-sample t-test model, indicated that a sample size of 45 participants would enable the detection of a 'small' effect (dz) of 0.43 between baseline and follow-up (two-tailed, alpha=0.05, power=0.80).

3.4 Data Collection

3.4.1 Resting haemodynamics. Resting HR and blood pressure (BP) was taken after the client had been in a supine position for 5 minutes in a quiet room. Resting HR was measured with a stethoscope and a stopwatch for 1 minute and compared with the values shown on the display screens of the cycle ergometer and electrocardiography (ECG) unit. Resting BP was measured manually three times with a stethoscope and aneroid sphygmomanometer, with the lowest BP reading being recorded. Rate pressure product (RPP) and mean arterial pressure (MAP) were mathematically calculated (RPP=Systolic BP (SBP)*HR; MAP=[(2*Diastolic BP (DBP)) + SBP] / 3.

3.4.2 Morphological measures. Stature was measured with shoes removed on a stadiometer. Body mass was measured on a daily calibrated electronic scale (Tanita, Model UM-051, Tokyo, Japan), with as much clothing as was practically possible removed. Body mass index (BMI) was calculated using height and weight data. Waist circumference was taken at the smallest circumference above the umbilicus or navel and below the xiphoid process. Percentage body fat was obtained using the six skinfold procedure at the triceps, sub-scapula, supra-iliac, abdomen (umbilicus), thigh and medial calf site, measured with Harpender callipers in accordance with the International Society for the Advancement of Kinanthropometry guidelines (Stewart, Marfell-Jones, Olds, & de Ridder, 2011). Body fat percentage was calculated using the Montreal Olympic Games Anthropometric Project six-site formula for males (sum of six skinfolds x 0.1051 + 2.59) and females (sum of six skinfolds x 0.1548 + 3.58) (Carter, 1982).

3.5 Functional Capacity

3.5.1 Cycle ergometry. All participants completed a modified version of the YMCA submaximal cycle ergometer testing protocol (ACSM, 2013). Testing was performed using a mechanically-braked cycle ergometer (Custo Med, Model ec3000, Ottobrunn, Germany). The test comprised of an unloaded 2-minute warm-up followed by three 4-minute stages. Participants started the test at 25 watts for the first stage, with power output increased for each consecutive stage depending on the participant's rating of perceived exertion (RPE), HR, BP, ECG and dyspnea responses. Power output was increased at the end of the 4th minute of each stage if a steady state HR (within five beats per minute

(bpm)) was achieved between the 3rd and 4th minute of each stage and if there were no symptom limits.

The aim of testing is for the participant to reach either 70.0% of their age-adjusted maximum HR or reach symptom maximum for RPE (15), SBP (250mmHg), DBP (115mmHg), dyspnea rating (≥4), angina (≥3), ST-segment change (>2mm) and/or onset of multifocal premature ventricular contractions. ACSM (2013) guidelines for test termination criteria, for both absolute and relative contraindications, were used to assess for and initiate early cessation of the test. Resistance was incrementally adjusted, based on the professional judgement of an experienced CEP, with the decision being based on HR response, RPE scoring, physical signs, BP response, and ECG reading. HR was manually recorded every minute of each stage using the ECG HR digital display and compared with the polar HR monitor reading on the cycle ergometer. In cases of disparity between the ECG and polar digital displays, the HR was manually checked with a stethoscope over 1 minute. Exercise BP was manually assessed during the last 30 seconds of each 4-minute stage.

Direct measurement of VO_{2peak} was done with respiratory gas analysis (Cortex Metalyzer 3B, Leipzig, Germany) used as a metabolic exercise testing system for complete cardiopulmonary exercise testing. Respiratory gas using breath by breath assessment was analysed in conjunction with 12-channel ECG. The ECG was used to monitor heart waveform and rhythm during exercise testing using modified electrode placement (McArdle, Katch, & Katch, 2010). Arm electrodes were positioned medial to the deltoid, 1-2 cm below the right and left clavicle. Mason-Likar electrode placement was used during the cycle ergometer test (Mason & Likar, 1966). Multistage equations were also

used to calculate each participant's functional aerobic (predicted) and muscular strength capacity. Patient VO_{2peak} values were generated, in line with predicted VO_{2max} values, from ergometer test results.

3.6 PA Assessment

3.6.1 ActiGraph wGT3X-BT Accelerometer. The ActiGraph PA monitoring device (ActiGraph wGT3X-BT, Florida, USA) is a tri-axial accelerometer for vertical, horizontal, and perpendicular axis movement, dimensioned at 4.6 cm x 3.3 cm x 1.5 cm and weighing 19 grams. The device incorporates microelectromechanical technology and objectively measures PA using accelerometry, ambient light, and a touch sensor as data collection endpoints. The device samples movement at rates ranging from 30 Hz to 100 Hz (user selectable), with data stored directly in a non-volatile flash memory in a raw, non-filtered/accumulated format as units of gravity (Dynamic Range +/- 8G). The accelerometer is highly sensitive and accurate to within ± 0.5% of the data collected. Ambient light data is sampled and stored in memory at a rate of 1 Hz.

The ActiGraph does not filter or accumulate data into epochs. Raw data is collected at the selected sample rate and is post-processed using data analysis software (ActiLife v 6.8.1 and later). Because these devices gather data from all sensors at all times users can generate native ActiLife, AgileGraph data (*.agd) files containing any combination of parametric data at a later date. Step counts and inclinometer data (available only when worn vertically on the hip) can be derived from accelerometry data during archive file or raw data (*.gt3x) decompression to *.agd format. The inclinometer helps users identify the orientation of the device and when the device itself is removed.

3.6.2 ActiGraph wGT3X-BT Accelerometer wear site. The optimal placement site for the device is the most lateral point on the right hip seated on the hipbone at a level approximately 2 cm to 5 cm below the umbilicus (Boerema et al., 2014).

3.6.3 Number of days monitored. Only six accelerometers were available to record PA. For this reason, the period of recording was staggered during a typical week, considering the need to measure both the pre-CR PA (for two patients inducted into the CR program) and post-CR PA (for two patients about to complete the CR program) of study participants within a week. Although accelerometer issue was staggered, all subjects were given the device for a complete week, e.g. issued Wednesday 2 pm, after pre-program consultation, and taken back 1 week later (Wednesday 1 pm). All participants were required to wear the device during the weekend days within their period of measure.

3.6.4 Pre-intervention physical assessment. Pre-intervention PA was measured using accelerometry. The cardiac patients were interviewed on inception to the CR program and informed of the program's syllabus, protocols and procedures, as well as inherent risks associated with program participation. A subjective, detailed medical history profile was also obtained from the patient, to ensure individualised, safe treatment was prescribed. Resting haemodynamics were recorded as described during data collection. The participants were instructed on the use and wearing of the device, but were only given specific details (ethics considered) so as not to affect test outcomes.

The accelerometer was worn continuously for 6 days during waking hours and when asleep. The only reason to remove the accelerometer was to

protect the device from becoming waterlogged or damaged through rough handling (bathing/showering, swimming, high-impact contact sports or pet destruction). For this study, participants received an hour-by-hour activity logbook into which they were asked to document all activities for the entire period of wear. The patients were instructed to annotate reason, time, and duration of accelerometer removal in the activity diary. They were also asked to maintain normal activity patterns and routines, avoiding the tendency to over-state activity levels just because they were documenting it and were wearing the accelerometer and polar HR monitor. Post-monitoring data analysis was compared to the diary time logs and notations.

The participants were asked to wear the accelerometer and polar HR monitor, immediately before starting with their formal exercise program. They were shown and received printed instructions on where and how to wear the accelerometer, and where to reposition it when they slept. Included in the analysis period were two weekend days. Data collected was processed as previously indicated.

3.6.5 During-intervention physical assessment. During-intervention PA was measured using the accelerometer and the daily feedback logbook. The assessment process followed the same format and structure as the pre-intervention physical assessment outlined above. Table 6.0 (Appendix A) graphically illustrates the general protocol that was followed with each study participant. As described, the study format for each participant involved pre-intervention patient analysis, to gain an understanding of their health condition, functionality, and physical ability before being prescribed targeted interventions. Throughout the intervention period, the patients were monitored for physical

response to prescribed exercise, with the exercise dose adapted accordingly. As part of the CR process, the patient was continually informed and educated about all aspects of their CR program according to their ability to understand. Throughout the duration of the intervention, each participant was administered as an individual case study (Appendix A: Table 6.0). On the final week of intervention, the patient was reassessed as per the pre-intervention assessment. Results and data outcomes are provided in the 'Results' section (Chapter 4).

3.7 Intervention Program Protocols

Participants exercised three times per week for no more than 60 minutes per session. The rest period was at least 48 hours between exercise sessions, but clients were instructed to maintain normal at-home PA patterns, which could include daily walks and engagement in group activities, such as playing bowls. Regarding the structured exercise program, the participants followed an individually prescribed exercise program that was designed in consideration of exercise guidelines from ACSM for chronically sick and elderly populations (ACSM, 2010; ACSM, 2003). These guidelines are the most appropriate for the population assessed in this investigation and have been collaboratively used by numerous international oversight councils, associations, and committees that deal with CVD prevention and treatment (Merz et al., 2009; Thompson et al., 2003). All participants were supervised/instructed during each exercise session by a trained CEP. Participants performed exercises at sub-maximal intensities based on the results of their fitness assessment administered at the beginning of the study.

ACSM exercise guidelines are based on the FITT principle, which provides the framework for prescribing exercises to CVD patients (outpatient CR). The design of the exercise intervention included aerobic (cardiovascular) and resistance (strength) exercises, as well as flexibility training. Patients performed aerobic exercise at every training session using an age-adjusted maximum HR intensity threshold of 40.0-80.0% of HR reserve (HRR). A subjective RPE scale was used to define exercise intensity (RPE of ≥11 to ≤16). Patients also performed resistance exercises at every training session, exercising subjects to an RPE scale score of 11 to 13 using loads that allowed 12 to 15 repetitions (ACSM, 2010; ACSM, 2003). Patients were required to continue taking prescribed medication during the intervention, and to ensure personal emergency medicine was immediately available while exercising. Consideration was given to the medications effect on the patient's physiological response, and capacity to exercise, such as β-blockers attenuating effect on HR (AACVPR, 2004; Schairer & Keteyian, 2006). Therefore, exercise prescription was based on the pre-intervention test results of appropriately medicated patients. Patients performed aerobic exercise at every training session using an age-adjusted maximum HR intensity threshold of 40.0-80.0% of HR reserve (HRR). A subjective RPE scale was used to define exercise intensity (RPE of ≥11 to ≤16). Patients also performed resistance exercises at every training session, exercising subjects to an RPE scale score of 11 to 13 using loads that allowed 12 to 15 repetitions (ACSM, 2010; ACSM, 2003). Exercise cadence (timing) accentuated the eccentric phase of the movement during each repetition (2 seconds concentric, 4 seconds eccentric), with rest periods between each set, and between each exercise, varying according to the patient's needs (20 seconds to 1 minute).

The format for each exercise session consisted of an initial check of patient well-being, sleep patterns, and physical recovery from the previous exercise session, before training, with haemodynamics monitored and recorded before, during, and after the exercise session. Aerobic exercise was performed by cycling on a stationary bike or arm ergometer, or by walking on a treadmill for approximately 5-25 minutes, with a warm up and cool down included. Resistance exercises were performed for approximately 15-30 minutes, incorporating six to 12 resistance exercises targeting the major muscle groups. Assigned resistance exercises for specified muscle groups included: chest (presses, flyes, and push-ups), back (rows, extensions), core (crunches, twists), arms (bicep curls, triceps extensions), and legs (presses, extensions, curls and calf raises). Resistance exercises were performed using weight machines, free weights (dumbbells, water-filled and medicine balls), elastic bands, and Swiss exercise balls. Flexibility exercises were conducted for approximately 5-10 minutes, and included stretches for the chest (doorway, elbows back and wall stretches), back (cat and camel and baby pose stretches), core (lateral twist and cobra stretches), and legs (hamstring, quad and calf stretches).

Guidelines for progressing exercise intervention based on participant adaptation to current exercise prescription is outlined by the ACSM, for resistance training (Ratamess et al., 2009) and aerobic training (Pollock et al., 1998). The ACSM (2013) also provides guidelines for safe practice and supervision during exercise, contraindications to exercising, and special considerations for cardiac patients.

3.8 Sample Characteristics

A Shapiro-Wilks test (Shapiro & Wilks, 1965; Razali & Wah, 2011), and a visual inspection of the histograms, normal Q-Q plots and box plots showed that the pre and post-training VO_{2peak} and EE scores were approximately normally distributed (males and females). Pre-training VO_{2peak} skewness scores were 0.454 (Standard Error (SE)=0.512) and 0.576 (SE=0.794) for males and females, respectively. The EE pre-training skewness score for males was 0.481 (SE=0.512) and 0.711 (SE=0.794) for females. The pre-training VO_{2peak} kurtosis scores were 0.930 (SE=0.992) for males and 2.00 (SE=1.587) for females, and the pre-training EE kurtosis scores were 2.377 (SE=1.587) for females and 1.467 (SE=0.992) for males. Post-training VO_{2peak} and EE skewness and kurtosis scores evidenced z-values within the -1.96 to +1.96 range, indicating approximately normal data distribution in terms of skewness and kurtosis.

3.9 Statistical Procedures

Statistical analyses were performed using SPSS (Version 24). Descriptive statistics are presented as means ± standard deviation. The data set presented with a normal distribution. A total of eight statistical procedures were conducted, including t-tests, correlations, and ANCOVAs.

Measures of functional capacity were correlated with accelerometer-determined PA/EE as part of the first aim. T-tests were used to assess the impact of the 12-week CR program on body composition, hemodynamic measures, functional capacity, and at-home PA measures

The impact of CVaM-capacity on PA patterns was investigated with two ANCOVAs, controlling for age and gender. The main aim with the ANCOVAs

was to determine if exercise-induced improvements in CV-capacity influence the relationships between stages of CV fitness (pre vs. post-CR) and accelerometer-determined PA patterns. For the purpose of the ANCOVAs, the participants were placed in three cardiovascular fitness groups based on the initial cycle ergometer test results. Participants were placed into the low (< 5.9 METs), mid (6.0 – 6.5 METs), or high (>6.5 METs) range fitness group based on the group distributions as determined by frequency tables. Those in the upper 30.0% of the group distribution were classed into the high range fitness group, while those in the bottom 30.0% were classified as the low fitness group.

Chapter 4 – Results

4.1 Introduction

The results of the study are reported in this chapter. The structure for presenting the results is related to the study aims. Baseline clinical characteristics of the study participants are tabled as 4-0. Assessment results, comparing the participants' pre-CR CV and muscular fitness with their recorded PA patterns, are listed in Table 4-01. The pre-intervention VO_{2peak} score spread and percentage of total recorded time spent at differing intensities are shown in Figures 4-01 and 4-02, respectively.

Tables 4-02 to 4-05 report the change in the value of body composition, haemodynamic, CV and muscular fitness, and PA variables, respectively, before and after the CR intervention. Tables 4-06 and 4-07 show the pre to post-intervention percentage change in VO_{2peak} and power output, compared with the participants' initial capacity. VO_{2peak} and power output is also compared with the participants' initial and post-intervention PA patterns, to assess correlation. The post-intervention VO_{2peak} score spread is shown in Figure 4-03, and is inclusive of pre-program results for comparison. Analyses of the relationship of VO_{2peak} with PA patterns are provided in Tables 4-08 to 4-11.

4.2 Clinical Characteristics of the Participants

The anthropometric, haemodynamic and lipid profile data of the participants' are reported in Table 4-0. Female participants comprised 26.0% of the total number of patients who completed the CR program. The participant cardiac diagnosis data presented is inclusive of both male and female patients. In total, three patients were diagnosed with 'Other' cardiac conditions. The

conditions included: cardiomegaly (n=1); valve stenosis (n=1); and valve replacement (n=1).

Table 4-0

CR Participant Baseline Demographic and Clinical Characteristics

Variable	Male (*n*=20)	Female (*n*=7)
	$\bar{X}$ (SD)	$\bar{X}$ (SD)
Age (yr)	60.45 (10.91)	61.86 (4.78)
Resting heart rate (bpm)	61.15 (11.41)	64.57 (10.40)
Resting blood pressure ($mm.Hg^{-1}$)		
Systolic	135.85 (23.04)	137.00 (11.96)
Diastolic	80.90 (7.64)	79.14 (3.80)
Weight (kg)	84.89 (12.67)	76.97 (10.24)
BMI ($kg.m^{-2}$)	27.74 (2.73)	29.63 (5.16)
Cholesterol ($mmol.l^{-1}$)		
Total	3.76 (1.12)	4.01 (1.04)
HDL	1.13 (0.23)	1.60 (046)
Triglycerides	1.31 (0.82)	1.51 (0.95)
Ratio (Tri:HDL)	3.41 (1.04)	2.73 (1.30)
Diagnosis; n (%)		
MI[(a)]	13 (48)	
PTCA[(b)]	5 (19)	
CABG[(c)]	4 (15)	
Pacemaker	2 (7)	
Other	3 (11)	

$\bar{X}$ =group mean; SD=standard deviation; (a) myocardial infarction; (b) percutaneous transluminal coronary angioplasty; (c) coronary artery bypass grafting.

4.3 Comparison of PF Measures with Accelerometer PA Data

The correlations between pre-CR CV and muscular fitness, and PA are reported in Table 4-01. Power output and VO_{2peak} correlate significantly ($p<0.05$) with accelerometry recordings of kilocalorie expenditure per week ($r=0.47$, and $r=0.53$). VO_{2peak} correlates statistically significantly with accelerometry determined moderate ($r=0.48$; $p=0.005$) and vigorous ($r=0.59$; $p=0.001$) PA. Power output also correlates significantly with vigorous PA ($r=0.44$; $p=0.03$), with a non-significant ($p>0.05$) negative correlation shown between power output and sedentarism ($r=-0.03$).

Table 4-01

Comparison of PF Measures with PA Participation

	Power Output (W)		VO_{2peak} ($ml.kg^{-1}.min^{-1}$)	
Variable	r[(c)]	p[(d)]	r	p
$kcal.wk^{-1}$[(a)]	0.47	0.007	0.53	0.002
Sedentary[(b)]	-0.03	0.433	0.13	0.266
Light[(b)]	0.14	0.240	0.32	0.051
Moderate[(b)]	0.28	0.076	0.48	0.005
Vigorous[(b)]	0.38	0.026	0.59	0.001

(a) kilocalories per week; (b) PA intensity; (c) correlation coefficient;
(d) level of statistical significance.

4.3.1 PF and PA pattern measures. The participants' pre-CR VO_{2peak} scores and recorded PA patterns (intensities) are graphically reported in Figures 4-01 and 4-02. respectively. Figure 4-01 outlines the spread of VO_{2peak} test scores (pre-CR range=10-29 $ml.kg^{-1}.min^{-1}$), and Figure 4-02 displays the study participants' total average volume of activity by categories of PA intensity.

The average time participants spent performing light to no activity (accelerometrically measured) summated to 98.2% (pre) and 98.4% (post) of the total recorded period (Fig. 4-02).

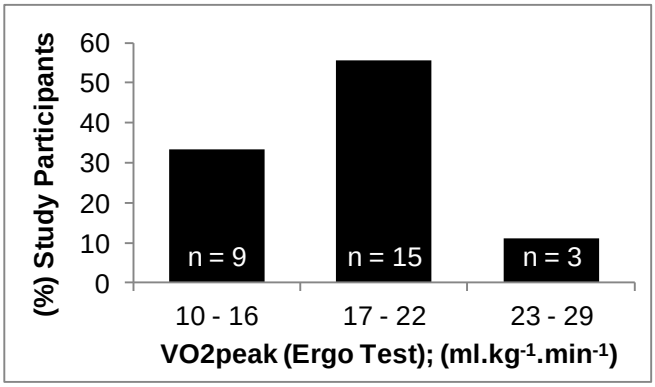

Figure 4-01. *Pre-CR Program Assessment-VO_{2peak} Scores*

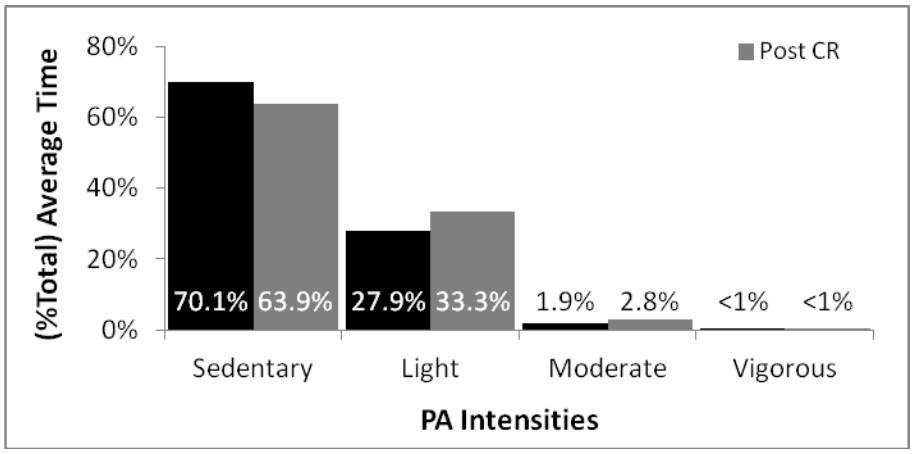

Figure 4-02. *Pre-Post CR Program Assessment Comparison – Participant Average Duration Spent at Each Intensity (Accelerometry Data)*

4.4 CR Program Effect on Body Composition Variables

The effects of the CR program on measures of body composition are reported in Table 4-02. There were no statistically significant changes over the 12 weeks relating to body weight, waist circumference and percentage of body fat.

Table 4-02

CR Program Effect on Body Composition Variables

Variables	Pre-CR Data $\bar{X}$[(a)]	(SD)[(b)]	Post-CR Data $\bar{X}$	(SD)	t[(c)]	P
Weight (kg)	82.84	(12.41)	82.95	(13.17)	-0.23	0.82
Waist circumference (cm)	98.19	(9.84)	95.24	(13.45)	0.75	0.46
Body fat (%)	21.31	(9.68)	20.51	(10.21)	1.43	0.16

(a) $\bar{X}$=group mean; (b) (SD)=standard deviation; (c) t-test (two tailed).

4.5 CR Program Effect on Haemodynamic Variables

The effects of the CR program on haemodynamic measures are reported in Table 4-03. Participant assessment results, after program completion, show improvement with all four variables. However, the only statistically significant ($p<0.05$) difference was the peak wattage that the participants could manage before reporting angina. Angina pectoralis occurrence relative to work rate increased 62.0% from a pre-program maximum work rate of 46.76 watts to a post-program work rate of 75.59 watts.

Table 4-03

CR Program Effect on Haemodynamic Variables

Variables	Pre-CR Data $\bar{X}$	(SD)	Post-CR Data $\bar{X}$	(SD)	t	p
Resting HR (bpm)	62.04	(11.06)	61.41	(11.15)	0.41	0.66
Systolic BP ($mm.Hg^{-1}$)	136.15	(20.52)	131.41	(20.60)	1.89	0.07
Diastolic BP ($mm.Hg^{-1}$)	80.44	(6.82)	78.59	(8.63)	1.53	0.14
Angina ST watts[(a)] (W)	46.76	(20.91)	75.59	(36.22)	-4.18	0.001

(a) Angina occurrence at the end stage/wattage of cycle ergometer GXT.

4.6 CR Program Effect on PF

The effects of the 3-month program on measures of CV and muscular fitness are reported in Table 4-04. The 3-month physical exercise program had a statistically significant ($p \leq 0.05$) effect on both measures of PF.

Table 4-04

CR Program Effect on PF

Variables	Pre-CR Data $\bar{X}$	(SD)	Post-CR Data $\bar{X}$	(SD)	t	P
VO_{2peak}(ml.kg^{-1}.min^{-1})	17.81	(4.62)	22.70	(5.60)	-8.60	0.000
Power output (W)	84.63	(31.01)	122.04	(48.00)	-7.10	0.000

4.7 CR Program Effect on PA

The effects of the CR program on PA variables are reported in Table 4-05. The change in activity patterns (volume and intensity) from pre to post-intervention, for all variables measured, is significant at the $p \leq 0.001$ level.

Table 4-05

CR Program Effect on PA

Variables	Pre-CR Data $\bar{X}$	(SD)	Post-CR Data $\bar{X}$	(SD)	t	p
kcal.wk^{-1}	6457.40	(1690.90)	5621.30	(1325.30)	-3.81	0.000
Sedentary	4528.20	(1259.98)	3590.44	(1077.69)	5.38	0.000
Light	1803.10	(596.43)	1871.30	(574.35)	-0.66	0.001
Moderate	125.00	(121.54)	157.37	(140.73)	-4.74	0.000
Vigorous	1.20	(3.41)	2.11	(3.97)	-2.89	0.000

The overall kilocalorie expenditure per week decreased statistically significantly ($p<0.05$) at re-assessment; however, the pre to post t-test results for calorie expenditure per week showed a 'negative' value. This disparity will be discussed in more detail in Chapter 5. It is probable that this disparity relates to the fact that participants did not wear the accelerometers for at least 1 hour, three times during re-assessment week, when training at the U-Kinetics CR centre. The at-home light, moderate, and vigorous PA caloric expenditure increased significantly ($p<0.05$) at re-assessment.

4.8 Relationship of Percentage (%) Change in PF with Pre-Intervention Measures of PF

The correlation between the pre to post-CR program percentage (%) change in CV fitness and pre-intervention PF variables are reported in Table 4-06. The data shows a negative correlation between percentage change achieved in CV fitness and both pre-intervention measures of PF, although it is not significant ($p<0.05$). The negative values mean that those with lower pre-training CV and muscular fitness achieved better relative post-training changes. In short, pre-training PF did not negatively influence CV fitness improvements achieved.

Table 4-06

Comparison of VO_{2peak} Change (%) with Pre-Training Measures of PF

	(%) Change VO_{2peak}	
Variables	r	p
VO_{2peak} ($ml.kg^{-1}.min^{-1}$)	-0.32	0.052
Power output (W)	-0.10	0.31

4.9 Relationship of Percentage (%) Change in CV Fitness with Pre and Post-Training Measures of PA

The correlation between percentage (%) change in CV fitness and pre and post-measures of PA are reported in Table 4-07. The data shows a larger correlation coefficient between achieved change in CV fitness and post-intervention PA patterns compared to pre-intervention patterns. Also, change in fitness shows a negative correlation with pre-intervention PA intensities. All correlations have a non-significant relationship ($p>0.05$). Those who made the best improvement in cardiovascular fitness did not present with higher participation in physical activity pre and post-intervention.

Table 4.07

Correlation of VO2 Change (%) with Pre and Post-CR Measures of PA

Variable	Time	(%) Change VO_{2peak} r	p
$kcal.wk^{-1}$	T1	0.21	0.14
	T2	0.31	0.06
Sedentary	T1	0.24	0.12
	T2	0.19	0.17
Light	T1	-0.03	0.45
	T2	0.04	0.43
Moderate	T1	-0.01	0.48
	T2	0.05	0.41
Vigorous	T1	-0.16	0.21
	T2	0.11	0.29

T1, pre-intervention assessment; T2, post-intervention assessment.

4.9.1 CV Fitness and PA pattern measures. The percentage of participants with CV fitness scores below 5.0 METs (VO_{2peak} ≤16.99), between 5.0 and 6.5 METs (VO_{2peak} – 17.00 to 22.99), and above 6.5 METs (VO_{2peak} ≥23) pre and post-training are graphically illustrated in Figure 4-03. Only three participants presented with a VO_{2peak} lower than 5.0 METs post-training compared to nine pre-training. In contrast, 10 participants presented with a VO_{2peak} higher than 6.5 METs post-training compared to only four who were at that level of pre-training.

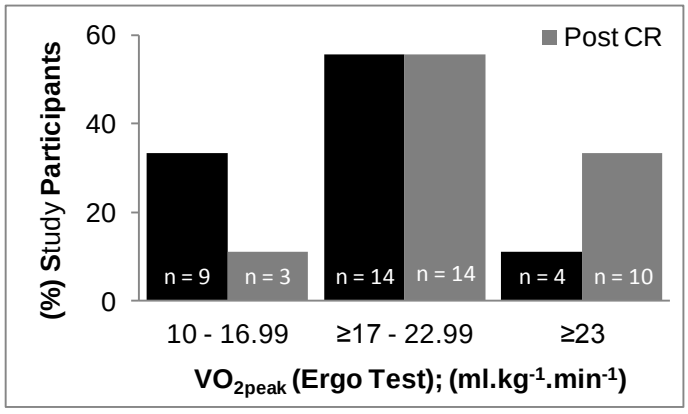

Figure 4-03. *Post-CR Program Assessment-VO_{2peak} Scores.*

4.9.2 Relationship of CV-capacity stages with PA patterns before and after exercise training in cardiac patients. The PF/PA pattern relationship was investigated using two ANCOVAs, controlling for age and gender. The aim was to determine the impact of CV fitness levels on PA patterns. The main question was, did exercise-induced improvements in PF strengthen the relationships between stages of CV-capacity (pre vs post-CR) and PA patterns? The results of these ANCOVAs are presented in Table 4-08. CV-stages became less predictive of mean VO_{2peak} variance post-training (68.0% (post) vs. 81.6% (pre)). Essentially, post-training CV capacity

contributed less to the variance of peak oxygen uptake (VO_{2peak}), probably due to the migration of individual patients across fitness categories.

Concerning the PA patterns, ETA^2 values indicate that post-training CVaM-capacity contributed more to the variances of kilocalories expended per week (25.7% vs. 9.6% (Table 4-08)) compared with pre-training CVaM-capacity. Post-training CVaM-capacity also contributed more to the variances of moderate PA (18.7% vs. 14.3% (Table 4-08)) and vigorous PA, EE (32.1% vs. 18.4% (Table 4-08)) than the pre-training CVaM-capacity stage.

Table 4-08

The F-ratio, p-values, ETA^2 and Wilks Lambda Scores of Two ANCOVAs≠ Investigating the Relationship of CV-capacity Stages with PA Patterns Before and After Exercise Training in Cardiac Patients

Dependent variables	ANCOVA groups	F-ratio	p-value	ETA^2 (%)	Wilks Lambda
VO_{2peak} ($ml.kg^{-1}.min^{-1}$)	CV-capacity stage (Pre)	48.71	0.001	81.6	18.4
	CV-capacity stage (Post)	24.46	0.001	68.0	31.0
$kcal.wk^{-1}$	CV-capacity stage (Pre)	1.17	0.33	9.6	90.4
	CV-capacity stage (Post)	3.76	0.04	25.7	74.3
Sedentary	CV-capacity stage (Pre)	0.72	0.49	6.2	93.8
	CV-capacity stage (Post)	0.40	0.67	3.5	96.5
Light	CV-capacity stage (Pre)	2.67	0.13	17.1	82.9
	CV-capacity stage (Post)	0.09	0.91	0.9	99.1
Moderate	CV-capacity stage (Pre)	1.84	0.18	14.3	85.7
	CV-capacity stage (Post)	2.53	0.10	18.7	81.3
Vigorous	CV-capacity stage (Pre)	2.48	0.71	18.4	81.6
	CV-capacity stage (Post)	5.21	0.02	32.1	67.9

≠ - statistically controlled for sex and age.

In contrast, post-training CV-capacity contributed less to the variances of sedentary behaviour (3.5% vs. 6.2% (Table 4-08)) and light PA (0.9% vs. 17.1% (Table 4-08)) caloric expenditure compared with pre-training CVaM-capacity. Further dissemination of data presented in Tables 4-09 to 4-11 explains these results.

Table 4-09

Pre and Post-Data of the Participants who had a CV Fitness < 5.9 METs at the Start and End of the Program

Variable	Time	n	T1 $\bar{X}$	T1 (SD)	T2 $\bar{X}$	T2 (SD)	P	ES	% change
VO_{2peak}	LowT1	9	13.11	2.15	17.56	3.28	0.006	1.36	33.9%
	LowT2	3	11.67	1.53	13.67	1.53	0.19	1.31	17.1%
$kcal.wk^{-1}$	LowT1	9	6419.30	1670.50	5754.60	1719.10	0.31	0.39	-10.4%
	LowT2	3	6246.80	505.10	5160.67	107.80	0.001	2.15	-17.4%
Sedentary	LowT1	9	4564.90	1164.20	3850.90	1438.00	0.001	0.50	-15.6%
	LowT2	3	4238.70	715.00	3435.00	682.90	0.19	1.12	-18.9%
Light	LowT1	9	1805.40	731.70	1820.60	501.50	0.01	0.02	0.8%
	LowT2	3	1969.30	641.30	1677.00	690.00	0.24	0.42	-14.8%
Moderate	LowT1	9	49.00	54.00	83.10	44.70	0.007	0.63	69.6%
	LowT2	3	38.67	47.90	48.67	43.70	0.04	0.21	25.8%
Vigorous	LowT1	9	0.00	0.00	0.00	0.00	-	-	-
	LowT2	3	0.00	0.00	0.00	0.00	-	-	-

LowT1=individuals who had a VO_{2peak} lower than 16.99 $ml.kg.min^{-1}$ at the start of the program; LowT2=individuals who had a VO_{2peak} lower than 16.99 $ml.kg.min^{-1}$ at the end of the program; ES=Cohen's effect size.

Sedentary behaviour decreased in all groups (Tables 4-09 to 4-11); hence, the lower contribution of post-training CVaM-capacity (3.5% vs. 6.2%) to the variance of sedentary behaviour in Table 4-08. Engagement in light PA seems to have changed to more moderate PA, as evident with the re-assessment groups performing less light, at-home PA (LowT2=14.8% decrease

shown in Table 4-09, and VigT2=3.4% decrease in Table 4-11). Consequently, the post CVaM-capacity stage contributed less to the variance of light PA than the pre CVaM-capacity stage (0.9% vs. 17.1%), as seen in Table 4-08.

Table 4-10

Pre and Post-Data of the Participants who had a CV Fitness of between 6.0 – 6.5 METs at the Start and End of the Program

Variable	Time	n	T1 $\bar{X}$	T1 (SD)	T2 $\bar{X}$	T2 (SD)	P	ES	% change
VO_{2peak}	MidT1	15	18.70	1.49	24.00	3.98	0.12	1.33	28.3%
	MidT2	14	16.40	2.98	20.40	1.56	0.003	1.34	24.4%
$kcal.wk^{-1}$	MidT1	15	6182.10	1134.50	5343.60	1741.30	0.12	0.48	-13.6%
	MidT2	14	5840.00	1636.90	5447.40	1763.60	0.001	0.22	-6.7%
Sedentary	MidT1	15	4368.60	1427.70	3403.50	869.70	0.02	0.68	-22.1%
	MidT2	14	4177.40	1275.10	3508.70	1306.70	0.001	0.51	-16.0%
Light	MidT1	15	1661.50	465.30	1754.50	500.00	0.08	0.19	5.6%
	MidT2	14	1586.10	596.10	1829.70	469.40	0.003	0.41	15.3%
Moderate	MidT1	15	151.20	125.20	183.70	157.50	0.001	0.21	21.5%
	MidT2	14	76.40	59.50	108.10	66.90	0.001	0.47	41.5%
Vigorous	MidT1	15	0.73	1.58	1.73	2.22	0.001	0.45	136.9%
	MidT2	14	0.07	0.27	0.71	1.64	0.87	0.39	914.3%

MidT1=individuals who had a VO_{2peak} between 17 and 22.99 $ml.kg.min^{-1}$ at the start of the program; MidT2=individuals who had a VO_{2peak} between 17 and 22.99 $ml.kg.min^{-1}$ at the end of the program.

Engagement in moderate at-home PA increased in all groups (Table 4-09 to 4-11); hence, the larger contribution of post-CR CVaM-capacity to the variance of moderate PA compared to pre-CR CVaM-capacity (18.7% vs. 14.3%). None of the participants with a VO_{2peak} lower than 16.99 $ml.kg.min^{-1}$ at the start and end of the 12-week CR program (n=9 vs. n=3) engaged in PA classified as vigorous. Participation in moderate PA did, however, improve

markedly in those two groups (LowT1=69.6% and LowT2=25.8% (Table 4-09)) after the 12-week CR training program.

The data in Table 4-10 indicates that both the MidT1 group (n=15) who were in the mid range fitness group at the start of the CR program, and the MidT2 group (n=14) who were in the mid range fitness group, post-CR program, did more vigorous PA after completing the 12-week CR program (MidT1, 1.73 kcal vs 0.73 kcal; MidT2, 0.71 kcal vs 0.07 kcal (Table 4-10)). The difference was only statistically significant (p=0.001) with the MidT1 group. The patients in the mid range fitness group at the end of the CR program (MidT2) were individuals who started in the mid range group (n=8) and individuals who migrated from the low range fitness group (n=6). This outcome influenced both the start ($\bar{X}$ =0.07 kcal), and end ($\bar{X}$ =0.71 kcal) values, and produced a comparatively high SD of 1.64 vs. a mean of 0.71 at T2 (Table 4-10).The result was a statistically non-significant (p>0.05), but very dramatic percentage change (914.3%), in the MidT2 group (Table 4-10). The resulting migration of individuals into different groups might also explain the light PA anomaly with the MidT2 group. The MidT2 group is the only re-assessment group that performed greater light PA compared with pre-assessment values, as evident in Table 4-10. In contrast, both the LowT2 and VigT2 groups performed less light PA compared with pre-assessment values (Tables 4-09 and 4-11).

At the end of the 12-week CR training program, 10 participants were placed in the vigorous (high range) fitness group (>6.5 METs) compared with three participants at the start of the CR program (Table 4-11). This data indicates that seven participants in the vigorously fit group (VigT2), at re-assessment, migrated from the mid range fitness group. The individuals in the

vigorous groups (VigT1 and VigT2) performed more at-home vigorous PA before and after the 12-week CR training program than the participants in the low and mid range fitness groups. This resulted in a comparatively small percentage change compared with the two 'mid' groups (MidT1 and MidT2). In summary, the data in Tables 4-08 to 4-11 indicate that at-home sedentary and light PA kilocalorie expenditure decreased after the 12-week CR exercise program, while moderate and vigorous PA increased.

Table 4-11

Pre and Post-Data of the Participants who had a CV Fitness >6.5 METs at the Start and End of the Program

Variable	Time	n	T1 $\bar{X}$	T1 (SD)	T2 $\bar{X}$	T2 (SD)	P	ES	% change
VO_{2peak}	VigT1	3	27.30	1.53	31.70	1.16	0.88	2.88	16.1%
	VigT2	10	21.60	4.12	28.70	3.57	0.03	1.70	32.4%
$kcal.wk^{-1}$	VigT1	3	7948.30	738.20	6607.30	462.90	0.60	1.82	-16.9%
	VigT2	10	7384.80	934.60	6002.90	1465.50	0.64	0.95	-18.7%
Sedentary	VigT1	3	5216.00	205.00	3743.70	964.40	0.06	1.53	-28.2%
	VigT2	10	5105.90	1328.50	3751.50	858.90	0.009	1.02	-26.5%
Light	VigT1	3	2504.00	282.90	2607.30	777.50	0.21	0.13	4.1%
	VigT2	10	2057.00	518.60	1987.80	706.10	0.24	0.10	-3.4%
Moderate	VigT1	3	221.30	159.70	248.70	182.80	0.09	0.15	12.4%
	VigT2	10	218.80	145.30	258.90	176.50	0.01	0.23	18.3%
Vigorous	VigT1	3	7.00	8.66	7.67	10.00	0.13	0.07	9.6%
	VigT2	10	3.10	5.19	4.70	5.46	0.001	0.29	51.6%

VigT1=individuals who had a VO_{2peak} higher than 23.00 $ml.kg.min^{-1}$ at the start of the program; VigT2=individuals who had a VO_{2peak} greater than 23.00 $ml.kg.min^{-1}$ at the end of the program.

Chapter 5 – Discussion

5.1 Introduction

This chapter discusses the results of this investigation, and how the data fits within current knowledge. The study aims of looking at the correlation between pre-CR CVaM-capacity and PA EE, and what effect the CR program intervention has on PA behaviour, are discussed separately. The limitations of this study are discussed, and recommendations are made, for the further development of research consequent to these findings. The relevant clinical application of understandings gained in the research is outlined, and conclusions given, in summation of the implications of this study.

In line with the study aims, the main findings of this investigation suggest that cardiac patients' CVaM-capacity is associated with their PA behaviour and that PA behaviour changes favourably over the period of CR intervention. These findings seem to support the hypothesis that CVaM-capacity is a predictor of PA habits/patterns and that CR intervention facilitates a change in at-home PA habits. A more detailed analysis of these findings is discussed in Sections 5.2 and 5.3.

5.2 Relationship of Pre-CR CVaM-capacity with Pre-CR PA Patterns

5.2.1 Volume of daily and weekly caloric expenditure. The first aim of this study was to observe whether the pre-rehabilitation functional ability of cardiac patients correlated with their pre-rehabilitation volume and quality of at-home PA. Does the fitter (VO_{2peak} and power output) cardiac patient perform more activity, and with greater intensity of effort, compared to the less fit patient before joining a CR program? Results from this analysis indicate a significant

relationship between CVaM-capacity and overall at-home PA behaviour (Table 4-01). Patient power output and peak oxygen consumption before the CR program showed a moderate, positive correlation with overall at-home caloric expenditure per week (r=0.47 and 0.53). The calculated r^2 values indicate that power output and VO_{2peak} contribute, respectively, 22.1% and 28.1% of the variance of weekly PA energy consumption.

No investigation was found that reported on the pre-CR CVaM-capacity/PA behaviour relationship of cardiac patients. Eaton's (1992; 1992a) meta-analyses of the risk of CVD development, relative to PA and CVaM-capacity, shows close similarities to this investigation. Similarities include: (a) both studies investigated at-home PA (kilocalories expended per intensity category), and CV-capacity (cardiorespiratory evaluation); and (b) both studies looked at the PA/CVaM-capacity interrelationship. The differences between the investigations were that: (a) Eaton analysed healthy individuals who had developed CVD in longitudinal investigations, opposed to individuals who already had CVD and (b) in Eaton's analyses, multiple epidemiological studies were assessed, which reflected larger subject numbers. Eaton's (1992; 1992a) investigations are somewhat relevant, considering the lack of direct subject matter data. Further, a pre vs. post-CVD development comparison should theoretically show a correlative association, whereas this study may be implied as a continuance of Eaton's investigations.

Both of the above-mentioned meta-analyses treated PA and CVaM-capacity as variables independent of other RF confounders (Eaton, 1992; Eaton, 1992a). As independently assessed variables, both PA and CVaM-capacity exhibited a strong inverse relationship with CHD. These two studies

(Eaton, 1992; Eaton, 1992a) essentially reported weak to moderate correlations (r=0.02 to r=0.44) between PA intensity and CVaM-capacity across the individual epidemiologic studies they analysed. This discrepancy of correlation data may be attributable to individual study differences, given the inter-study disparity of variables assessed and the incorrect classification of PA (Eaton, 1992a).

5.2.2 Intensity of at-home PA. Peak oxygen consumption correlates statistically significantly ($p<0.05$) with moderate ($r=0.48$) and vigorous ($r=0.59$) at-home caloric expenditure (Table 4-01). In contrast, VO_{2peak} correlates weakly with sedentary ($r=0.13$) and light PA ($r=0.32$), as indicated in Table 4-01. A similar trend is seen with power output, although correlation coefficients ranged from a weak to moderate positive (vigorous, $r=0.38$), to a weak negative (sedentary, $r=-0.03$) correlation. This trend seems to indicate that the higher the level of CV-fitness the more likely individuals are to engage in moderate and vigorous at-home activity and that they are, compared to those with lower levels of fitness, less sedentary and less engaged in light activity.

Eaton (1992a) suggests that CVaM-capacity change may be attributable to genetic disposition, and/or disability (either disassociated with or due to sedentarism), rather than PA correlated change (Eaton, 1992a). The patient's physical capacity to exercise or engage in PA may be inhibited, not only by cardiovascular fragility (post-MI weakness or myocardial injury) but also by an actual muscular-skeletal injury. PA is known to maintain muscle tone, inhibit enervation, and facilitate joint mobility, all mechanisms that aid CVaM-capacity maintenance/improvement (McArdle et al., 2010). As an implication, the longer the patient stays physically inactive after a cardiac event, the higher the

likelihood of a vicious cycle where chronic inactivity facilitates progressive functional disability and vice versa. In the current study, maximum cycle power output (which is influenced not only by physical inactivity but also by factors such as leg strength, body weight, and cardiovascular discomforts, like tiredness or angina) correlates slightly less with PA patterns than VO_{2peak}. The fact that VO_{2peak} correlates slightly better with PA patterns than power output suggests that PA patterns might be influenced more by cardiovascular ability than muscular ability in this group of participants. Body weight is a confounding variable that needs to be considered as well because it influences power output positively and oxygen consumption negatively. It can be assumed that the chronically inactive patient will be less able to perform activity due to functional disability at the initial stages of CR intervention. However, there is sparse research that investigates the contribution of musculoskeletal factors to functional/training disability in cardiac patients. Improved understanding may facilitate the development of guidelines that directly address the debilitating PA/PF corrosion cycle and help formulate potentially superior treatment strategies and recovery outcomes for cardiac patients.

5.3 The Effect of the CR Program on Clinical Variables

5.3.1 Physical fitness/cardiovascular capacity/functional capacity. CR is shown to improve PF, with an incurred effect for CVD RFs, disease progression/regression, and reduced mortality (Lear & Ignaszewski, 2001). Figure 4-03 depicts the CVaM-capacity change occurring within the study population over the course of the CR program. A comparison of pre to post-CR peak oxygen uptake shows a significant improvement of VO_{2peak} scores. The mean VO_{2peak} score increased from 17.81 to 22.70 $ml.kg.min^{-1}$. The mean

maximum wattage that patients could handle during the last stage of the GXT increased from 84.6 watts to 122.0 watts. Patients with a VO_{2peak} of 40 $ml.kg.min^{-1}$ (~5% probability for all-cause, and ~2% for CV mortality) showed an 80% lower all-cause, and a 90% lower cardiovascular mortality risk, compared to patients with a VO_{2peak} of 12 $ml.kg.min^{-1}$ (~25% probability for all-cause, and ~22% for CV mortality) (Vanhees, Fagard, Thijs, Staessen, & Amery, 1994).

5.3.2 Body composition. The CR intervention program had a small effect on body composition variables. The changes were, however, not statistically significant ($p>0.05$). During the 12-week intervention program, dietary interventions were not enforced; therefore, no effect on body weight/ BMI was expected. Two clinical studies of similar duration (~3 months) that measured patient weight loss after CR training showed an overall mean weight loss of 0.6% (Brochu, Poehlman, Savage, Fragnoli-Munn, & Ades, 2000), and a 0.6% loss for non-obese patients (BMI=25.0–29.9 kg.m-2) compared to a 1.8% loss for obese patients (BMI=30.0–39.9 kg.m-2) (Bader, Maguire, Spahn, O'Malley, & Balady, 2001), respectively. In the current study cohort, only a small number of subjects could be classified obese pre-CR. For instance, only four respondents met the criteria for Stage 1 (30.0–34.9 kg.m-2) obesity, and only two respondents could be classed as Stage 2 (35.0–39.9 kg.m-2) obese. Additionally, the results in Table 4-02 are reflective of the data spread between gender groups (weight – (male; (m)) = 84.89 kg-1 vs. (female; (f)) = 76.97 kg-1; body fat (%) – (m) = 17.28% vs. (f) = 32.81%).

5.3.3 Haemodynamics. Patient haemodynamics changed positively but mostly non-significantly ($p>0.05$) over the course of the 12-week CR program. Results in Table 4-03 show a positive effect on resting HR and BP. Most

importantly regarding the potential effect on exercise behaviour was the statistically significant effect of the program on the wattage at which participants reported angina, which increased from 46.80 watts to 75.60 watts.

What this data indicates is that patients were physically lighter, markedly fitter, and had lowered susceptibility to angina (managing more exercise before experiencing angina) during PA after the 12-week intervention program. It is therefore not unrealistic to propose/expect that the above-mentioned physical changes should impact positively on at-home exercise behaviour.

5.4 The Effect of a CR Program on PA Patterns

The second aim of this study was to observe whether the cardiac patients at-home PA patterns changed during/after completion of the 12-week supervised CR program. . Results measuring the change in PA patterns (volume and intensity) showed significant statistical change at the $p \leq 0.001$ level (Table 4-05). Light, moderate, and vigorous at-home PA increased by 101.48 $kcal.wk^{-1}$ after the 12-week supervised CR program. In contrast, overall EE decreased by 836.10 $kcal.wk^{-1}$ (6457.40 – 5621.30=836.10 $kcal.wk^{-1}$), with sedentary EE decreasing by 937.76 $kcal.wk^{-1}$ (4528.20 – 3590.44=937.76 $kcal.wk^{-1}$ (Table 4-05)). A deficit is apparent when calculating the total decrease in EE (pre to post-CR=836.10 $kcal.wk^{-1}$). This deficit (836.10 $kcal.wk^{-1}$) can be explained by the exclusion of 3 hours of accelerometer recording during re-assessment. The PA behaviour re-assessment (second accelerometer wearing) occurred during the last week of the 12-week supervised CR intervention at U-Kinetics. Participants were instructed not to wear the accelerometers during the 3 weekly training sessions at U-Kinetics because the aim was to only monitor changes in at-home PA.

The data presented in Tables 4-08 to 4-11 show that changes obtained with both VO_{2peak} and PA behaviour are not significantly negated by the patients' starting CVaM-capacity. Participants present with reduced sedentary EE in all fitness categories at re-assessment, with the highly fit groups (VigT1 and VigT2) achieving higher percentage reductions (28.2% and 26.5% (Table 4-11) vs 15.6% and 18.9% (Tables 4-09)). The three most fragile individuals (pre and post-CR, VO_{2peak} <17.00 ml.kg.min^{-1}) presented with an 18.9% reduction in sedentary EE and a 25.8% increase in moderate at-home PA (Table 4-09). The corresponding sedentarism reduction and increased moderate PA indicates an increased confidence and ability to engage in activity at home after a supervised CR program, including those with the most restrictive CVaM-capacity. It is also important to note that the 12-week CR program produced a nearly identical percentage change in VO_{2peak} for participants who had the lowest (LowT2=17.1% (Table 4-09)), and highest (VigT1=16.1% (Table 4-11)) VO_{2peak} values at the start of the program.

None of the participants who started in the low fitness group (VO_{2peak} <17.00ml.kg.min^{-1}) engaged in vigorous PA during pre and post-assessment. This lack of behaviour change indicates that the participants stayed within their physical limitations when engaging in PA at home. This is a significant result within the context of CR. Considering that the low fitness group engaged in more moderate PA, but performed no vigorous PA, indicates that from a psychological perspective the program positively affected participant confidence to engage in PA and helped produce a better understanding of how to do so safely. From a physiological perspective, it is important to note that 66.7% of participants (n=6) who started in the low CV-capacity group (VO_{2peak} <17.0

ml.kg.min^{-1}) migrated to the moderately fit group, presenting with a 33.9% mean increase in CV-capacity at re-assessment. This group also achieved a 69.6% increase in moderate PA, indicating that although physiologically restricted, they made significant improvements with both CVaM-capacity and at-home PA engagement.

Participants in the highly fit groups (VigT1 and VigT2) evidenced the highest at-home engagement in vigorous PA before and after the 12-week rehabilitation program. This data shows that the exercise capacity of a cardiac patient does impact on the quality (intensity and volume) of PA that the patient performs pre and post-supervised CR program. Overall the VO_{2peak} percentage change did not correlate significantly with re-assessment PA behaviour for the entire study population (Table 4-07). The pre to post-change in VO_{2peak} showed a negative correlation with pre-intervention PA patterns. This negative relationship indicates that 'physiological trainability' was associated with pre-training PA patterns, but was not the primary determinant of post-CR at-home PA-patterns.

Schairer et al. (1998) found that only 17.0% of CR patients maintained exercise above levels that promote health (300 kilocalories per session). Similarly, Savage et al. (2000) found caloric expenditure per CR session was inadequate, and in both studies was reflective of insufficient weekly caloric expenditure. The data presented in this thesis seems to suggest that it is not principally EE that produces these outcomes, but the fact that the patients learned how to challenge their CV systems safely with exercise. A 5-year follow-up of the Schairer et al. (1998) study showed that 72.0% of participants expended ~1000 kcal.wk^{-1}, with 43.0% of participants performing over 1500

$kcal.wk^{-1}$ (Schairer et al., 2003). This long-term outcome suggests that patients might over time increase their EE with exercise as their fitness and confidence increases.

5.5 Limitations

5.5.1 Sample size. A small sample size is noted (n=27) and was expected, due to the 'real time' rehabilitation management of the participants, over the period of data collection. The overall goal of this study was to investigate the effectiveness of a supervised CR program on CVaM-capacity measures and at-home PA-patterns. In this context, data collected here will only support a generalised interpretation.

5.5.2 Accelerometry. The methodology outlines the viability of accelerometry PA measurement. One limitation of accelerometry is patient adherence to wearing protocols. It is uncertain whether the patients wore the accelerometer continuously over the period of assessment. Although a minimum wear time was imposed, to be counted as a recorded day, this is not a true reflection of habit. A logbook was issued, to improve patient compliance to the wear protocols and to record hourly PA and periods of sleep. Good compliance was seen with logbook recordings, although a small number of recordings lacked sufficient detail to be included for analysis. Incidentally, it is uncertain whether the initial recording period and CR program produced a learning curve on the bias of the post-assessment wear procedure. Additionally, in an attempt to mitigate for subjective recording error the patients were asked to ''maintain normal activity patterns and routine, avoiding the tendency to over-state activity levels just because they were documenting it and were wearing

the accelerometer'. However, it is acknowledged that the instruction to 'portray' a behavior may have influenced the patient's PA patterns.

The primary aim of this study was to investigate the effect of the supervised CR program on at-home PA-patterns. Patients were asked not to wear the accelerometer during training at the CR centre in the last week of the 12-week program when re-assessment was done. This produced 3 hours (3 training sessions per week, 1 hour per session) less wear time per week, and affected the total amount of kilocalorie expenditure for the re-assessment week. It is also possible that patients reduced their at-home vigorous activity in that last week because they considered that they had already performed their weekly high-quality training at the CR centre. In hindsight, it may have been better to apply the accelerometer re-assessment in the first week after cessation of the 12-week training program. The reason why the reassessment was done in the last week of supervised training relates to preventing equipment/data loss. Also, some of the poor CR responders traditionally get a re-referral, meaning they do not stop but continue their training at the CR centre for another 12 weeks. In that case, the poor respondent data would then have been rejected as part of the final analysis. The poor respondent data provided some of the best insights and, fortunately, was not lost to analysis.

5.5.3 Definition of Intensity. It is possible that patients classified with a low range of fitness did not migrate to the vigorously fit group due to a difference in objective and subjective definitions of intensity. Objective parameters were absolutely defined, with intensity levels graduated within a progressive and fixed range. This may not have reflected the perceived intensity

of activity that the low fitness patient may be experiencing. This disparity will also skew results, although the extent of bias has yet to be quantified.

5.5.4 PF Assessment Protocol. The only protocol available to this project was cycle ergometry assessment which allowed the examiner to measure the patient's physiological response to exercise from a stable platform without impeding correct biomechanical movement. Additionally, the burden of body weight was minimised by sitting, and the patient could self-supported using the handle bar. However, the more appropriate protocol to use is a treadmill assessment, where the patient bears their full body weight, whilst employing the biomechanical movement of walking, typically the preferred mode of locomotion in daily life compared with cycling. Future assessment, where possible, should employ measurement protocols specific to patient PA behavior.

5.5.5 Individual vs. general application. A disparity between each patient's results for the measurement of PA habits relative to levels of PF inhibits the generalisation of data. The nature of CR intervention within this study was to treat each cardiac patient individually according to their particular affliction and functional ability. Attenuation of disease types to a generalised CVD categorisation, and identifying mean (SD) and correlation average, allowed for a very general interpretation of results. To be able to apply learned outcomes to the individual patient would require blinded clinical testing, with compared groups pair matched to solve the problem of association. This task will prove to be difficult given the numerous RF variable associations requiring investigation. Currently, available research has only investigated major

associations, where more detail that is unique to all RFs is necessary to be applicable to the individual patient's intervention program.

5.6 Future Research

This study investigated measurement techniques for assessing PA habits/patterns. No clear association (trend) is shown between participant scores, which inhibits any ‘generalisation’ of results to the wider CVD population. The task of forming generalised concepts requires the identification of common occurrences that factor in the CVD cause and effect paradigm. A comprehensive investigation of RF aligned assessment/testing protocols is needed to identify the individual level of exposure per RF. While it is assumed that our current understanding of CVD risk factors is comprehensive, these factors only describe genetic, habitual and physiological associations. Other variables should be included in successive investigations to assess levels of influence. The encompassing model of care, Te Whare Tapawha, identifies a holistic approach to wellbeing. While we assessed taha tinana (physical, physiological) variables for intervention effect, taha wairua (spiritual), taha hinengaro (mental and emotional), and taha whānau (support elements, family, environment), aspects of health and wellbeing also require interventive investigation.

The design of the CR program must align with the goals and outcomes sought for the patient. A review of topical research attests to the benefits attending a CR program has for the cardiac patient’s morbidity and mortality risk; however, questions raised by our study require further investigation. Although a strong to moderate relationship is shown between PA and PF at high intensities (moderate to vigorous PA), the question remains, why is this not

the case at the lower intensities (sedentary to low PA)? Given that greater dose/response is seen with PF at these lower intensities (Fig. 2.01), what other factors/variables are responsible aside from PF? The CEP cannot assume that low PA will reflect relatively low CVaM-capacity. Current research lacks sufficient information to facilitate a detailed investigation of program intervention characteristics for treating each individual RF. The ability to identify how, or if, these features contribute to the causality of achieved outcomes will facilitate the construction of a highly effective CR program.

5.7 Clinical Applications

This study is an analysis of an operational CR clinic, with specific intervention protocols applied to the CR patient. The results of this study are directly applicable to the CR program and show that a peripheral investigation of RFs may show a greater correlation with low CVaM-capacity, although these RFs have yet to be identified. Therefore more appropriate assessment tools may be required to identify the more appropriate RF. The results achieved here are a progressive step toward a refined, accepted CR protocol that directly addresses causality.

5.8 Conclusion

In summary, this study investigated whether the cardiac patient's CVaM-capacity is associated with their PA behaviour before and during CR program participation. The results of the investigation show a moderate to strong association between the patient's at-home volume of activity and their CVaM-capacity. Also, the total time spent at the higher intensities of activity (moderate to vigorous) seems to predicate CVaM-capacity. In contrast, the time spent at

light to no activity was not predictive of CVaM-capacity. This seems to indicate a causal relationship between CV-ability and the intensity of at-home PA in cardiac patients. However, more research is required to clarify whether there is indeed a causal relationship.

This study also investigated whether CR program participation has an effect on changing a cardiac patient's PA patterns. Investigation results show a significant increase in PA habits and a significant decrease in sedentary behaviour during involvement in a CR program. Unless the cardiac patient presents with serious pathological trainability issues (abnormal physiological response during light and moderate exercise), they should be encouraged to perform moderately intense activity/exercise extra to CR to achieve greater health benefits and improve CVaM-capacity.

The results of this study show encouraging health-related trends; however, gaps in understanding still exist. Barriers to CR participation should be minimised to expedite an epidemiological and multi-clinical investigation that isolates individual RF impact on CVD. Data gained from multi-clinical research, when applied, will improve our understanding of the disease and maximise health benefits for the patient.

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Appendix A

Table 6.0

Flow diagram of PA assessment before and during CR intervention

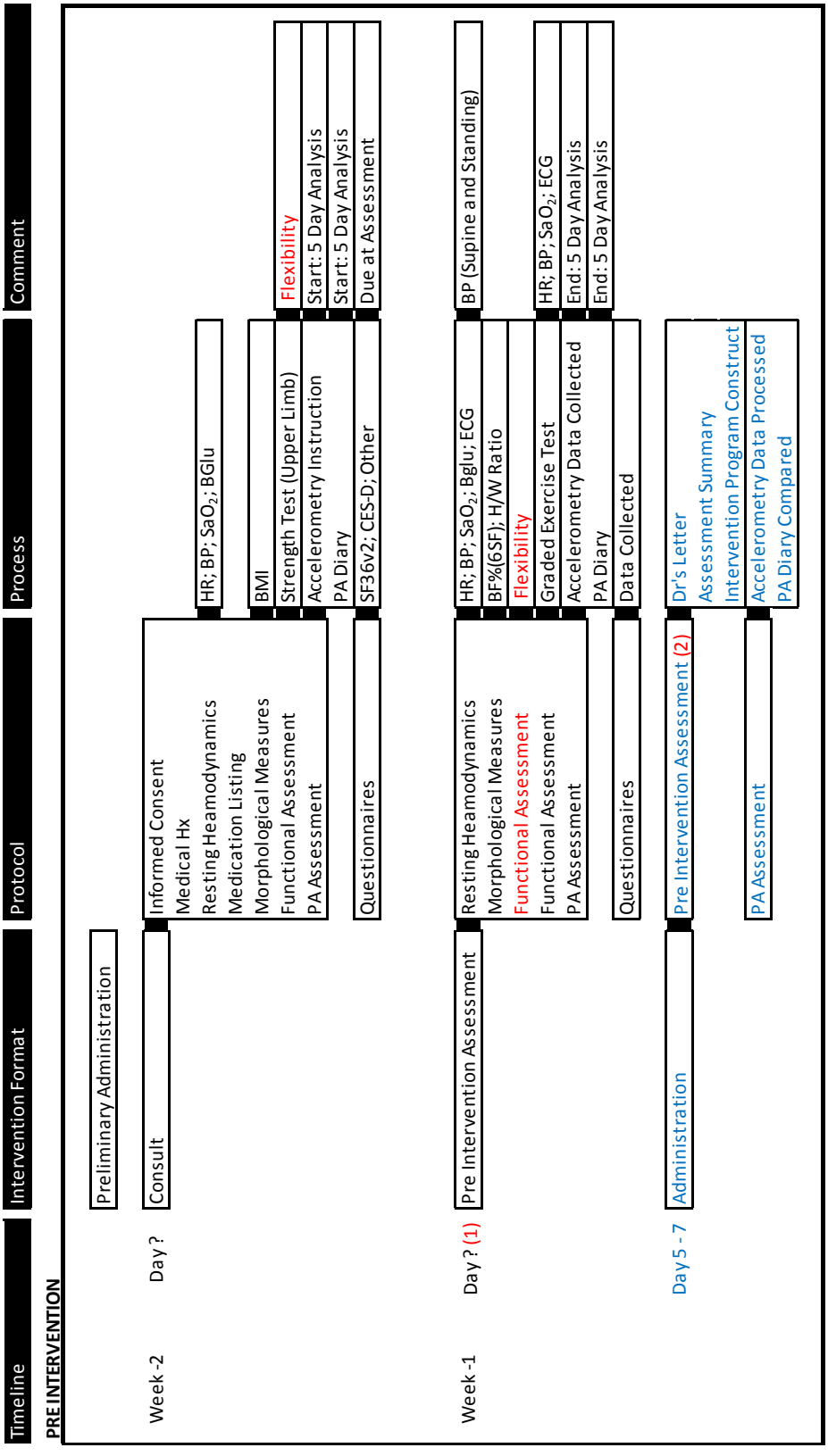


Table 6.0 Continued

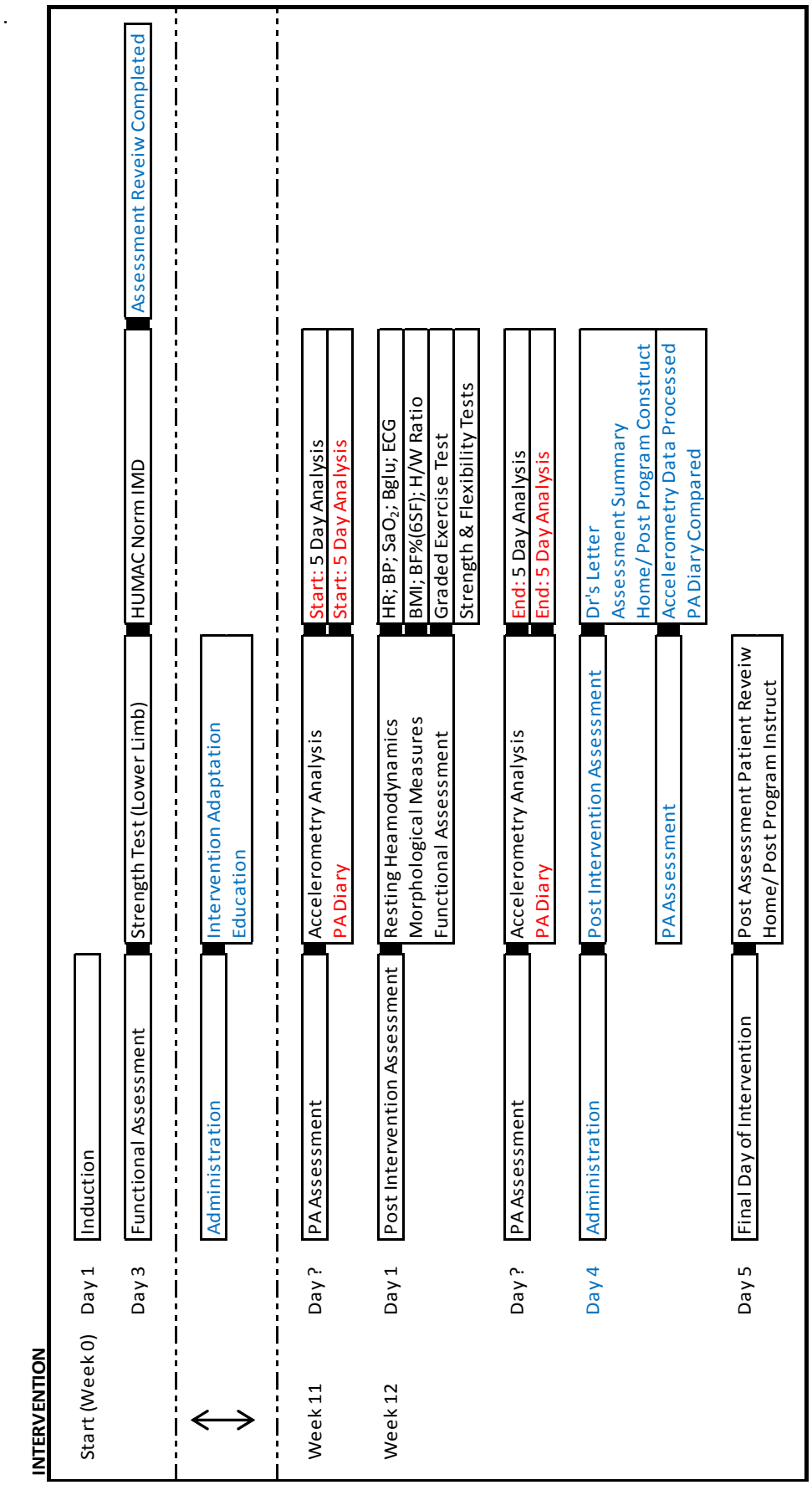
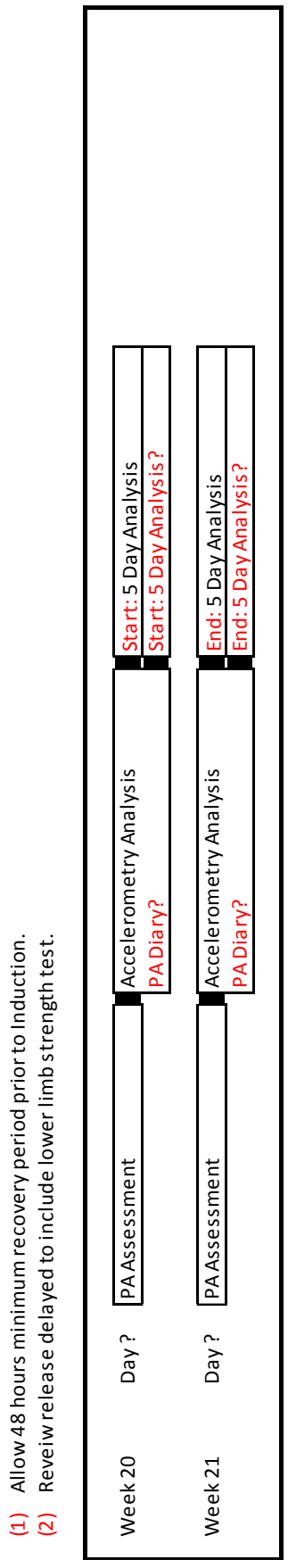


Table 6.0 *Continued*



Appendix B

Participant Information Sheet

Project title: ***Change in physical activity during active treatment of cardiac patients***

Project Supervisor: ***A/Prof Lukas Dreyer***

Researcher: ***Leon Tahana***

An Invitation

Kia Ora.

My name is Leon Tahana and I am a Clinical Exercise Physiologist at U-Kinetics. Currently I am working towards my Masters qualification through Auckland University of Technology (AUT) and doing a research project that investigates the change in physical activity during active cardiac rehabilitation treatment of cardiac patients. Your participation in the research is entirely voluntary and you may withdraw at any time, even before all the data has been collected. If you withdraw, or choose not to participate, your referral to U-Kinetics will not be affected in any way. That is, you can still participate in the 12 week exercise training program that your doctor referred you to and you can still learn about (and personally experience) the benefits of regular supervised training. All people referred to U-Kinetics are allowed to attend the clinic three times a week (for about an hour each time) all fully funded by UCOL and MidCentral DHB and each person participates on a voluntary basis.

My research needs volunteers living with cardiovascular disease (CVD), and who are able to train three times per week during the operational hours of the clinic (Monday, Wednesday & Friday: 8am – 5pm; Tuesday & Thursday 8am -12noon).

What is the purpose of this research?

The purpose of this research project is to assess whether the functional ability (physical fitness) of cardiac patients before participating in the Ukinetics cardiac rehabilitation (CR) program, reflects the level of physical activity (PA) performed at home, at work, during sport or at play. The study will also look at whether the at home physical activity patterns of a cardiac patient change during participation in U-kinetics CR program.

One component of the exercise that we use at U-kinetics is cycling on a stationary bike. The difficulty (also known as “intensity”) of the cycling is entirely based your fitness and will be designed to be at a comfortable level. Another component of the exercise is resistance training (gym machines) and this is also used by us to help people with CVD. Both these exercise components are done under the safe supervision of Clinical Exercise Physiologists (CEPs) who will fully monitor you (e.g. Heart rate, blood pressure and blood sugar levels).

This study will essentially measure levels of PA before you enter the CR program. This will involve you wearing an accelerometer, similar to a pedometer; which measures your movement and interprets these movements as energy expended (caloric expenditure). We will also ask you how much activity you perform normally over the course of a week via a PA questionnaire (International PA Questionnaire (IPAQ)). This will give us data that we can compare with tests we will perform with you prior to you starting CR. These tests will

evaluate your functional ability (flexibility, strength, balance) and physical fitness (a graded exercise test on an ergocycle (stationary bike)). These same tests and measurements will be performed at the end of the 12 week CR program. This data will give us information on how effective our CR program is for producing necessary PA change.

As part of my qualification I will use the data obtained from your participation to write my thesis document, to write academic papers and oral presentations at scientific conferences. I will not include your name in any of these documents/presentations - only the results achieved from the data we have collected.

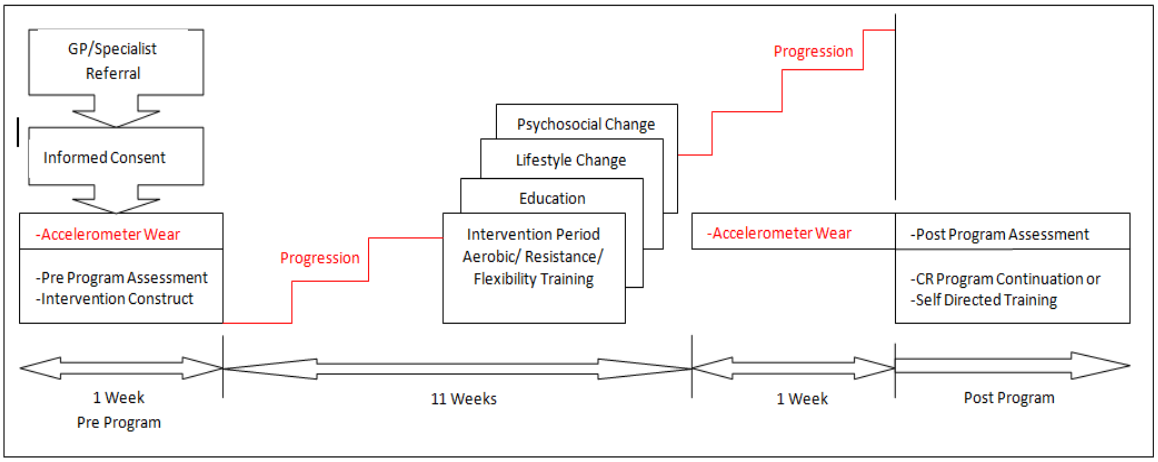
How were you identified and why are you being invited to participate in this research?

From the notes that your doctor sent on your behalf to U-Kinetics (to get you enrolled on the funded program) we determined that you meet the entry requirements of my study (male or female having been recently diagnosed with CVD) and as such I want to invite you to attend a face-to-face meeting where we can meet each other and discuss the research further (and answer any questions you may have).

In order to ensure safety this study will only include participants who do not have serious heart problems (low ejection fraction, uncontrolled angina, aneurysm etc.), muscle or joint concerns (e.g. A recent knee replacement). Remember that if you are not able to participate in my research project you will still be able to train at U-Kinetics as per your referral.

What will happen in this research?

The picture below shows the timeline of my research. At the start and end of the CR program, there will be an assessment designed to see how you have progressed over the 12 weeks.



Pre Program: You will receive an appointment time during which you will be fully informed about the tests and procedures that will be performed as part of the research project and the U-kinetics program. During this initial session you will be able to ask questions to clarify points and issues. Prior to acceptance onto the program you will be asked to sign a form stating that you understand and consent to the processes involved in your CR program.

Following the informed consent process exercise testing will be conducted. All exercise testing is based on exercise testing protocols that may include, but are not limited to:

Cardiovascular Exercise Testing: This will provide an estimation of your cardiorespiratory fitness. You will perform an easy-to-moderate exercise test on a stationary bicycle or other equipment determined by U-Kinetics. The exercise intensity will begin at a low level and will be advanced in stages depending on how your body responds to each stage of the test. Most clients will also have ECG stickers attached around their heart during this test so that accurate recordings of the cardiac rhythms can be viewed. A face mask will be worn to collect expired air data that will indicate aerobic fitness and a safe end point for testing. In

some circumstances a finger-prick blood sample may be needed to update your glucose or cholesterol readings.

Musculoskeletal Testing: This will provide information as to the functional capabilities of your muscles and the joints to which they attach. This may include range of motion (flexibility) tests and other general, and/or computer-aided, muscular strength and endurance testing, and balance testing.

Body Composition Assessment: This will provide data that will be used to help calculate baseline values in order to track program effect. These measurements include standing on a scale as well as the measuring of selected skinfold thicknesses and/or girths. During many of the tests it will be to your advantage to wear minimal clothing and/or loose fitting clothing so that accurate measurements can be recorded.

Physical Activity Assessment: This will provide an estimation of your caloric expenditure and physical activity habits. This will include wearing a waist strap fitted with a small accelerometer unit. Period of wear will be for 6 days; before starting, and at the end of the 12 week exercise program. A log book with self recorded activities performed over the same periods will also be included in the assessment.

Other Measures of Health Status: Additional tests may be performed depending on your health status. These may include tests such as spirometry, peak flow, blood glucose and blood lipids (e.g. Cholesterol).

As part of a research project, this data collected will aid in assessing and tracking the effectiveness of the U-Kinetics exercise program. This data will also be used to construct your exercise intervention program. The 12 week exercise program I will design for you is based on assessment results and will be in line with international recommendations for people with cardiovascular disease and similar health conditions.

Intervention Period: For 12 weeks you will train 3 times per week for about an hour each session. Here you will conduct aerobic exercise (stationary bike or treadmill), resistance training (weight machines, free weights and other equipment) and some flexibility exercises. The program will be progressed in intensity and or duration as you physically adapt to the prescribed exercise regime. During the 12 weeks ongoing information will be provided and discussed with you regarding your CVD condition and applicable/associated lifestyle. This will essentially target aspects that we think you may need to adapt, rethink and/or change because doing so will aid with your rehabilitation process and improve your personal outcomes. At week 11 you will again be asked to wear an accelerometer unit to measure your caloric expenditure and physical activity patterns.

Post Program: A post program testing battery -the same as your pre-program testing- will be performed to assess for any changes after you have completed the 12-week exercise program. Reports will be constructed and issued to you and to your referring GP/ Specialist. If applicable you may be invited to attend a further 12 weeks of training to elicit further improvements to your health. You are welcome to continue training by yourself in your home or local gym and U-Kinetics staff will provide you with a home-based exercise program for that purpose. Up to this point the only aspect that will be different for you in comparison to individuals going through the normal U-kinetics program, is the wearing of the accelerometer.

What are the discomforts and risks and how will they be alleviated?

The face-to-face meetings and assessment sessions take place in a private consultation room, but there may be a fourth-year student present to help with the note-taking. I will be asking you questions related to your medical conditions (reading what your doctor wrote in his referral letter), medications and activity levels - so that I get a better understanding of how CVD is affecting you and your ability to exercise safely.

Most of the assessments are done with you in a relaxed state (e.g. Height, weight, blood pressure, body fat). To obtain an accurate picture of your heart rhythm I may need to shave small areas of your chest (if very hairy) so that the electrodes stick better (and are not painful when pulling them off afterwards).

However, there is one test that may place some strain on you. This test is necessary in order to determine your safe exercise limits and strength results. The first is a stationary cycling test which will start off very easy and where I will regularly monitor your heart rate and rhythm (via the ECG images) and blood pressure. Only if you are safe to continue to the next level of the test, will I make it slightly more difficult.

I have been safely helping people to exercise for the past 3 years, but just in case, all staff members and students of U-Kinetics are trained regularly in first-aid and resuscitation, and there is an AED (portable defibrillator) and oxygen cylinder on site - which is checked daily.

What are the benefits?

The potential benefits to you include:

- Enhanced understanding of CVD complications
- Regular blood pressure checks
- Regular body mass monitoring (to help with weight loss motivation)
- Better understanding the effects of exercise (immediate and long-term) on CVD
- Knowledge, experience and confidence to continue exercising by yourself

This research will benefit me by providing me with:

- Understanding of how exercise affects CVD
- Data for the completion of my Masters qualification

There is potential for a wider-community understanding to how exercise effects:

- The CVD state
- A reduction in future disease and death rates
- A reduction in the associated health care expenses
- Improved productivity through return to work

Additionally, all student helpers will be exposed to how research is conducted so that they may, in the future, build on this experience.

What compensation is available for injury or negligence?

In the unlikely event of a physical injury as a result of your participation in this study, rehabilitation and compensation for injury by accident may be available from the Accident Compensation Corporation, providing the incident details satisfy the requirements of the law and the Corporation's regulations.

What are the costs of participating in this research?

During the entire program only travel and time costs will be your responsibility. All the assessments and supervised training is fully-funded by UCOL and the MidCentral DHB. The car parks at, and around, U-Kinetics are free (60 minute time limit for on road parking).

Post program you may take your training program with you and you can continue to exercise regularly (if you wish) either at home or in your community, but this will not be funded.

What opportunity do I have to consider this invitation?

You will be given a week from our first face-to-face meeting to talk to your whanau/family before needing to decide whether to accept the invitation (or not) .

How do I agree to participate in this research?

At our first face-to-face meeting I will explain the process again, give you a tour of the assessment and training facilities and give you a consent form. Once you are satisfied that I have answered all your questions relating to the research you may consider signing the form.

Will I receive feedback on the results of this research?

After each assessment week you will receive feedback on your results. At the completion of the research I will give a presentation at U-Kinetics to which all participants will be invited.

Data storage and future use:

All information is treated as confidential and information is recorded on documentation that will be secured in a file and locked away in a filing cabinet behind the reception desk. Electronic data will be stored in a secure data set on the UCOL network. Only people directly involved in the research will have access to the data. The data we record will/may also be published in scientific journals or used in presentations, however you will not be identified.

What do I do if I have concerns about this research?

Any concerns regarding the nature of this project should be notified in the first instance to the Project Supervisor, *Assoc. Prof. Lukas Dreyer, l.dreyer@ucol.ac.nz,* (06) 592 7001 x70636

Concerns regarding the conduct of the research should be notified to the Executive Secretary of AUTEC, Kate O'Connor, *ethics@aut.ac.nz* , 921 9999 ext 6038.

Whom do I contact for further information about this research?

Please feel welcome to contact me, or my supervisor, should you have any questions:

Researcher contact details:

Leon Tahana
(06) 354 2866

Project supervisor contact details:

Assoc. Prof. Lukas Dreyer
UCOL
(06) 592 7001 x70636

Approved by the Auckland University of Technology Ethics Committee on type the date on which the final approval was granted AUTEC Reference number type the AUTEC reference number

Appendix C

Consent Form

Project title:	***Change in physical activity during active treatment of cardiac patients***
Project Supervisor:	***A/prof Lukas Dreyer***
Researcher:	***Leon Tahana***

- ○ I have read and understood the information provided about this research project in the Information Sheet dated 11 November 2014
- ○ I have had an opportunity to ask questions and to have them answered.
- ○ I understand that I may withdraw myself or any information that I have provided for this project at any time prior to completion of data collection, without being disadvantaged in any way.
- ○ I understand that notes will be taken (by Leon Tahana and/or fourth year students) during the interviews.
- ○ If I withdraw, I understand that all relevant information and transcripts, or parts thereof, will be destroyed.
- ○ I agree to take part in this research.
- ○ I wish to receive a copy of the report from the research (please tick one): Yes ○ No ○
- ○ I understand that the data will be secured and only accessible to the research team
- ○ I understand that my test results will be sent to my GP

Participants signature: .....

Participants Name: .....

Participants contact details (if appropriate):

.....

Date:

Approved by the Auckland University of Technology Ethics Committee on type the date on which the final approval was granted AUTEC Reference number type the AUTEC reference number

Note: The Participant should retain a copy of this form.

Appendix D

Front Page Omitted

U-KINETICS EXERCISE & WELLNESS CLINIC

Health Screen

AUT UNIVERSITY TE WĀNANGA ARONUI O TAMAKI MAKAU RAU

Medical Information

Have you ever had a graded exercise stress test? YES NO

Date and Place of Test:

_____

Have you ever had any cardiological tests (e.g. ECG)? YES NO

Date and Place of Test:

_____

HOSPITALISATION: Details of your recent hospitalisations

Year *Location* *Reason*

_____

_____

Person to contact in case of an emergency:

_____

Phone: _____ *Relationship:* _____

PERSONAL HEALTH HISTORY

Have you ever had a heart attack? YES NO

If yes,

*when?*_____

Have you ever had a heart operation? YES NO

If yes, which procedure and where (and when) was it done?

- Cardiac catheterization _____
- Coronary angioplasty (PCI) _____

- Pacemaker _____
- Other _____

Have you been diagnosed with a heart condition? YES NO

If yes, which condition and when was it diagnosed?

- Heart valve disease _____
- Heart failure _____
- Arrhythmia of the heart_____
- Heart murmur _____
- Congenital heart disease _____
- Other_____

While resting, do you experience pain/discomfort in the chest, neck, jaw or arms? YES NO

During physical exercise do you experience any chest discomfort? YES NO

Do you get strange sensations in your lower legs when walking short distances? YES NO

Do you experience unreasonable breathlessness (day or night)? YES NO

Do you ever experience any dizziness, fainting, or blackouts? YES NO

Do you ever get significant swelling of your feet (ankle oedema) YES NO

If yes to any of the above questions, please explain how often?

_____

_____

Have you been diagnosed with any of the following health conditions? YES NO

If yes, when first diagnosed and how is it currently managed?

- Diabetes _____
- Asthma or other lung disease _____
- High Blood Pressure_____
- High Cholesterol levels_____
- Musculoskeletal problems that limit your physical activity

  _____

- Other_____

MEDICATION *Dosage & times/day*

CONSULTATION NOTES:

FAMILY HISTORY

- Have any immediate family members had a heart attack, coronary revascularization (heart bypass) or suddenly died. YES NO

  Relationship and their age at time of incident: _____

- Have any immediate family members been diagnosed as having:

  - High Blood Pressure YES NO
  - High cholesterol levels YES NO
  - Gout YES NO
  - Obesity YES NO
  - Diabetes YES NO
  - Congenital heart defects YES NO
  - Stroke YES NO
  - Cancer YES NO
  - Lung diseases YES NO
  - Neurological diseases YES NO
  - Immune diseases YES NO
  - Other YES NO

  If you responded YES to any of the above conditions please elaborate:

  _____

Approved by the Auckland University of Technology Ethics Committee on type the date on which the final approval was granted AUTEC Reference number type the AUTEC reference number

Appendix E

Booklet Front Page Omitted

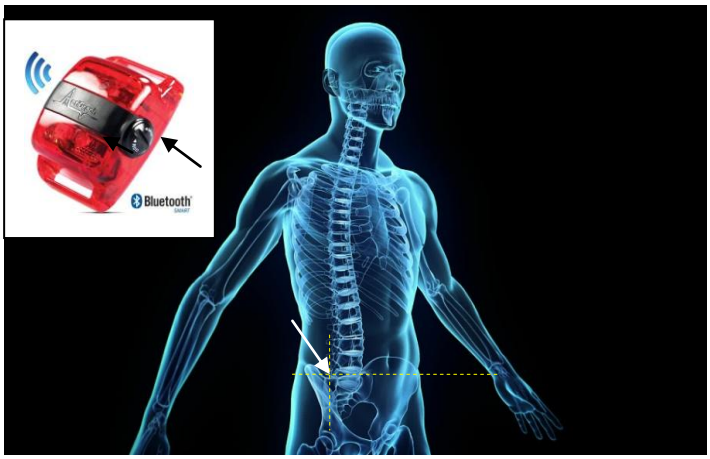
U-KINETICS EXERCISE & WELLNESS CLINIC

Physical Activity Booklet Log

AUT UNIVERSITY TE WĀNANGA ARONUI O TAMAKI MAKAU RAU

Actigraph wGT3X-BT User Instructions

Wear Location: The device will be worn below the waist approximately 2 to 5cm below the umbilicus (belly button), so that the device sits on your right hip bone, most lateral position (Figure. 1), using the elastic belt/ adhesive belt clip to ensure secure device fixation to the body. A small black bump on one side of the device (Insert) should always be facing upwards when the belt is in the correct position.



During sleep the device may be moved to the front of the hip, for a more comfortable sleep. Reposition on waking.

Wearer Issues: Although manufacture materials are not known to be irritating to the skin, some irritation to individuals with sensitive skin may occur. If irritation does occur consult your doctor for treatment, stop wearing the device, and notify Ukinetics Clinic as soon as possible (contact details below).

Device Removal: Please remove the device when getting wet. Remove the device while taking a bath or shower, or while swimming. Also remove when playing very rough contact sports or activities, i.e. for karate or rugby. Please annotate reason, time and duration of removal in the log (as shown).

Device Handling:

1. Keep devices away from pets and other animals that may chew on, bite, urinate on, swallow, and destroy the device.
2. Putting the device in a microwave will destroy various parts of the device and may completely destroy the device.
3. Do not put the device in extreme cold or hot temperatures and do not apply any electrical sources to the device.

Red LED (Fault Indicator):

No Flashing (LED Off)	Normal operating condition
2 Flashes	Low battery. The unit needs to be recharged.
3 Flashes	Unexpected battery failure or battery has entered halt mode

You will wear the device for 5 days (3 week days and 2 weekend days), from 8pm on day 1 to 8am on day 5. Please contact Ukinetics Clinic if the red LED is flashing as soon as possible:

Contact Ph: 12345678 (Substituted) Contact Cell: 12345678

Daily Physical Activity Log

Date ____________________

Time	Activity	Duration	Time	Activity	Duration
AM			PM		
6:30	Awake		6	S	1hr30min
10	L	1 hr	11:30	Sleep	

Activity Key

S	Seated (Reading, Watching TV)	1	At Home
L	Light Activity	2	During Work
M	Moderate Activity	3	At the Gym
H	Heavy Activity	4	During Recreation

Signs and Symptoms of Cardiac Distress

Signs and symptoms

Although some heart attacks are sudden the majority start slowly, with mild pain or discomfort. Confusion may lengthen the time taken to get help. Knowing the signs and symptoms will reduce time to intervene and may be lifesaving.

Signs vary as follows. The pain may:

- Initially come and go
- Be in one or both arms (more commonly the left)
- Go into your neck, back, jaw, stomach and abdomen

and the chest may feel like:

- squeezing
- pressing
- tightness
- fullness
- pain

You may have one or more of the following symptoms with or without chest pain/discomfort:

- sweating
- feeling faint
- feeling sick
- vomiting
- being short of breath

Even if you're not sure it's a heart attack, have it checked out.

Date:

Approved by the Auckland University of Technology Ethics Committee on type the date on which the final approval was granted AUTEC Reference number type the AUTEC reference number

Appendix F **Copy Only**

21 October 2015

Scott Duncan
Faculty of Health and Environmental Sciences

Dear Scott

Re Ethics Application: **15/352 Change in physical activity during active treatment of cardiac patients.**

Thank you for providing evidence as requested, which satisfies the points raised by the Auckland University of Technology Ethics Committee (AUTEC).

Your ethics application has been approved for three years until 21 October 2018.

As part of the ethics approval process, you are required to submit the following to AUTEC:

- A brief annual progress report using form EA2, which is available online through http://www.aut.ac.nz/researchethics. When necessary this form may also be used to request an extension of the approval at least one month prior to its expiry on 21 October 2018;
- A brief report on the status of the project using form EA3, which is available online through http://www.aut.ac.nz/researchethics. This report is to be submitted either when the approval expires on 21 October 2018 or on completion of the project.

It is a condition of approval that AUTEC is notified of any adverse events or if the research does not commence. AUTEC approval needs to be sought for any alteration to the research, including any alteration of or addition to any documents that are provided to participants. You are responsible for ensuring that research undertaken under this approval occurs within the parameters outlined in the approved application.

AUTEC grants ethical approval only. If you require management approval from an institution or organisation for your research, then you will need to obtain this. If your research is undertaken within a jurisdiction outside New Zealand, you will need to make the arrangements necessary to meet the legal and ethical requirements that apply there.

To enable us to provide you with efficient service, please use the application number and study title in all correspondence with us. If you have any enquiries about this application, or anything else, please do contact us at ethics@aut.ac.nz.

All the very best with your research,

Kate O'Connor
Executive Secretary
Auckland University of Technology Ethics Committee

Cc: Leon Tahana leontahana@gmail.com, l.dreyer@ucol.ac.nz