DETERMINING THE FEASIBILITY OF THE CARDIAC REHABILITATION PARADIGM AND ITS IMPACT ON EXERCISE SELF-EFFICACY AMONG CHRONIC KIDNEY DISEASE PATIENTS: A PILOT STUDY

by

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Abstract

**Background:** Patients with chronic kidney disease (CKD) are in the “highest risk” group for cardiovascular disease (CVD) and nephrology guidelines recommend referral to cardiac rehabilitation (CR) to prevent its development. However, there is limited evidence supporting this recommendation and as few as 10% of patients with CKD utilize this service. In the general population, CR has been shown to enhance cardiovascular (CV) health and exercise self-efficacy (SE). Among persons with CKD, evidence suggests that CR may be an effective tool to improve CV health; however, no studies regarding its impact on exercise SE have been conducted. Given the low utilization of this service among patients with CKD, it is necessary to determine accrual and retention rates to inform the potential for a larger systematic trial. The primary goals of our study were to: (a) determine recruitment and enrollment ratios of patients with CKD to CR; and (b) examine changes in exercise SE across their participation in a CR program.

**Methods:** A retrospective chart review was undertaken at the Nephrology Program at Kingston General Hospital. Charts were screened for demographic information and clinical descriptors. Eligible participants were offered enrollment in a 16-week CR program; where exercise SE, CVD risk factors, self-management behaviours, and physical function outcomes were measured.

**Results:** A total of 611 charts were reviewed. Of those eligible for inclusion, 7 individuals were recruited to the study (recruitment ratio = 4.6%); however, only 3 were retained for enrollment (enrollment ratio = 2.0%). The lack of physician endorsement and travel distance may have contributed to the low enrollment. Across the course of their participation in CR, exercise SE was observed to change by +12.8%, -5.3%, and +11.5% from baseline to discharge for each participant, respectively.
Conclusions: This is the first study to: (a) quantify the feasibility of recruiting and enrolling persons with CKD in CR and (b) describe monthly changes in exercise SE via a case series. Evidence supports the hypothesis that CR is a potentially powerful agent to improve exercise SE among patients with CKD; however, further work is needed to elucidate barriers and facilitators to CR enrollment, and the relationship between exercise SE and participation in this health service.
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List of Abbreviations

30CST – 30-second chair stand test
ACSM – American College of Sports Medicine
BBS – Berg Balance Scale
BMI – Body mass index
BP – Blood pressure
CDSMP – Chronic Disease Self-Management Program
CHD – Coronary heart disease
CI – Confidence interval
CKD – Chronic kidney disease
CPG – Clinical practice guideline
CR – Cardiac rehabilitation
CRC – Cardiac Rehabilitation Centre
CV – Cardiovascular
CVD – Cardiovascular disease
DASH – Dietary Approaches to Stop Hypertension
DBP – Diastolic blood pressure
DM – Diabetes mellitus
ECG – Electrocardiogram
eGFR – Estimated glomerular filtration rate
ESRD – End-stage renal disease
EXT – Exercise training
GFR – Glomerular filtration rate
GXT – Graded exercise tolerance test
HbA1c – Glycated hemoglobin
HDH – Hotel Dieu Hospital
HDH-CRC – Hotel Dieu Hospital-Cardiac Rehabilitation Centre
HDL-C – High-density lipoprotein cholesterol
HR – Heart rate
HRpeak – Peak heart rate
HRresting – Resting heart rate
HTN – Hypertension
HzdR – Hazard ratio
*KDIGO* – Kidney Disease: Improving Global Outcomes
*KGH* – Kingston General Hospital
*LDL-C* – Low-density lipoprotein cholesterol
*MDC* – Minimal detectable change
*MDC_{95} – Minimal detectable change at the 95% confidence interval
*MET* – Metabolic equivalent
*MI* – Myocardial infarction
*MSES* – Multidimensional Self-Efficacy for Exercise Scale
*NCEP* – National Cholesterol Education Program
*OR* – Odds ratio
*PA* – Physical activity
*PKC* – Protein kinase C
*QOL* – Quality of life
*RARE Score* – Risk of Activity Related Events Score
*RCT* – Randomized control trial
*RM* – Repetition maximum
*ROS* – Reactive oxygen species
*RPE* – Rating of perceived exertion
*RR* – Relative risk
*RRT* – Renal replacement therapy
*SBP* – Systolic blood pressure
*SCT* – Stair climb test
*SE* – Self-efficacy
*SEM* – Standard error of measurement
*SFA* – Saturated fatty acid
*SM* – Self-management
*SMS* – Self-management support
*STS* – Sit-to-stand
*TC* – Total cholesterol
*TG* – Triglyceride
*U.S.* – United States
*VO_{2peak} – Maximal oxygen consumption
*WMD* – Weighted mean difference
Glossary

Cardiac rehabilitation – The enhancement and maintenance of cardiovascular health through individualized programs designed to optimize physical, psychological, social, vocational, and emotional status. This process includes the facilitation and delivery of secondary prevention through risk factor identification and modification in an effort to prevent disease progression and the recurrence of cardiac events (Stone, Arthur, Austford, & Blair, 2004).

Exercise – Physical activity that is planned, structured, repetitive, and purposive in the sense that improvement or maintenance of one or more components of physical fitness is an objective (Caspersen, Powell, & Christenson, 1985).

Physical activity – Any bodily movement produced by skeletal muscles that results in energy expenditure (Caspersen et al., 1985).

Secondary prevention – The sum total of all interventions, physiological and behavioural, designed to favourably modify an individual’s lifestyle and enhance adherence and compliance with long-term behaviours compatible with minimizing disease progression (Stone et al., 2004).

Self-efficacy – “… belief in one’s capabilities to organize and execute the courses of action required to produce given attainments” (Bandura [pp.3], 1997).

Self-management – An individual’s ability to manage the symptoms, treatment, physical, psychosocial, and lifestyle changes inherent in living with a chronic condition (McGowan, 2007).

Self-management programs – Empower individuals to cope with disease and live better quality lives with fewer restrictions from their illness by developing self-efficacy, which is the level of confidence that an individual has in his or her ability to succeed in dealing with their own chronic disease (McGowan, 2007).
Chapter 1

Introduction

Chronic kidney disease (CKD) is a health condition occurring in the presence of structural and/or functional damage to the renal system. Associated with its diagnosis are multiple physiological and metabolic disturbances, including hypertension (HTN), cardiovascular (CV) complications, impaired physical function, and hormonal imbalances; all of which are linked to poor health outcomes. Within the Canadian healthcare system, this disease has become a public health concern due to: (a) the high prevalence of CKD; (b) the high economic cost associated with managing this condition; and (c) the increased risk for adverse health consequences.

Worldwide prevalence rates of CKD range from 4-16% in adults over the age of 18 (Amato et al., 2005; Brown et al., 2003; Cirilli et al., 2006; Coresh et al., 2007; McDonald, Maguire, & Hoy, 2003; Nitsch et al., 2006; Zhang & Rothenbacher, 2008). In Canada, an estimated 2.9 million adults (or roughly 12.5% of the population) are affected by this condition (Arora et al., 2013). While the vast majority of individuals with CKD are in the early stages of the disease (i.e. Stages 1-2), the final stage of CKD (i.e. Stage 5, also known as end-stage renal disease [ESRD]) is not only increasing in prevalence but also creating a significant financial burden on our society. In 2013, there were approximately 41,931 persons with ESRD in Canada; with 57.5% (24,114) on dialysis (either hemodialysis or peritoneal dialysis) and 42.5% (17,817) living with a functioning kidney transplant (Canadian Institute for Health Information, 2015). Despite innovative strategies to treat the consequences of renal failure, the majority of patients with ESRD must rely on long-term dialysis to replace their lost kidney function. The financial burden associated with maintaining such treatments is high, with traditional in-centre
hemodialysis costs estimated to be in excess of $70,000 annually per patient (Kroeker et al., 2003). Efforts to find less expensive alternatives, such as home hemodialysis programs, have been made; however, the costs of these programs are still significant ($60,000/year per patient). Consequently, the estimated cost for Canadian hemodialysis patients receiving care in 2013 was almost $1.7 billion. Although the use of such treatments has improved survival rates among dialysis patients in recent years, individuals with CKD are still at high risk for early mortality due to other co-morbidities.

In 2011, Statistics Canada listed CKD as the 10th leading cause of death in Canada; representing 1.4% of all-cause mortality (or a total of 3,294 deaths) (Statistics Canada, 2011). This value is likely even higher than reported as deaths from other causes also contribute to mortality within this population. Individuals with CKD, specifically, experience a 10 to 30 fold increased risk of death from CV disease (CVD) – such as coronary heart disease (CHD), myocardial infarction (MI), and stroke – compared to the general population (National Kidney Foundation [NKF], 2002; Vlagopolous & Sarnak, 2005). Mortality from these consequences represents over 50% of all CKD deaths compared to only 19% from renal failure itself, prompting the National Kidney Foundation to recommend all persons with CKD to the “highest risk” group for developing CVD (NKF, 2002). Given the increased risk for CVDs among renal cohorts, nephrology guidelines have recommended the primary and secondary prevention of these conditions; specifically, through engaging in cardiac rehabilitation (CR) programs (NKF, 2002).
Cardiac Rehabilitation is a multi-faceted approach to the management and mitigation of physical and social disabilities caused by CV-related consequences. Inherent to its structure is the provision of individualized CVD risk factor therapies, behaviour modification strategies, and therapeutic exercise. In order to deliver such diverse components, CR is of necessity multi-disciplinary and inter-professional; employing the services of nurses, exercise specialists, dietitians, psychosocial counsellors, administrators, and physicians to achieve its goals. The collective involvement of all personnel and treatments is what produces the comprehensive nature of CR; resulting in improved health outcomes such as exercise capacity, obesity indices, and lipid profiles, alongside the reduction of inflammation, psychological distress, and CV morbidity and mortality rates (Lavie & Milani, 2011). As with any intervention, the maintenance of positive health outcomes is imperative to the long-term effectiveness of a therapy. To ensure changes persist upon completion of CR, this service utilizes behaviour change interventions – in conjunction with education and coaching strategies – to provide patients with the necessary self-management (SM) skills they need to understand both heart healthy and unhealthy behaviours. The provision of these tactics ultimately allows patients to manage the physical, social, and emotional elements of their condition, and helps them transition from receiving consistent on-site support to becoming active self-managers. Given that CKD is a progressive condition needing the daily maintenance of its symptoms, renal patients stand to gain significant benefits from SM strategies to control their health consequences.

Self-Management includes a wide range of behaviours including the engagement in preventive activities, to managing adverse complications, to adhering to strict treatment regimens (Barlow, Wright, Sheasby, Turner, & Hainsworth, 2002). Through the integration of such activities and recommendations, chronic disease patients are better able to prevent complications,
maintain optimum health status, and minimize the intrusion of the disease into their preferred lifestyles (Lin, 2005). Accordingly, SM should be viewed as a multi-dimensional concept that combines biological, psychological, and social activities (Barlow et al., 2002). Research pertaining to SM behaviours among patients with CKD has demonstrated that communication, partnership in care, self-care activities, medication and/or treatment adherence, and self-advocacy are necessary in order to manage renal consequences (Curtin, Mapes, Schatell, & Burrows-Hudson, 2005; Gallant, 2003; Hill-Briggs, 2003). Each of these behaviours is inherently built into the CR paradigm, whereby this service provides patients with: problem-solving tactics to identify their symptoms and possible causes for health consequence; decision-making strategies to improve symptom management by using many different techniques; exercise, nutritional, and psychosocial resources; and healthcare provider partnerships where patients are taught how to access and use medical care in their community (Hill-Briggs, 2003; Lorig & Holman, 2003).

What is not apparent, however, is whether SM behaviours are sustained in the long-term among those with CKD participating in this service. Currently, no studies have investigated: (a) whether changes in self-directed activities occur after engaging in CR or (b) the factors which influence adherence to self-directed activities. One characteristic that has been shown to impact compliance to SM activities is self-efficacy (SE).

Self-Efficacy is a key factor in changing self-directed behaviours among the general population (Bandura, 1977a, 1977b, 1997; Schwarzer & Fuchs, 1996). This independent predictor of SM is defined as an individual’s judgment of their capability to organize and execute actions needed to perform an activity, and is largely influenced by past performance and accomplishments (i.e. mastery experiences) (Bandura, 1977a, 1977b, 1997; LaPier, Cleary, & Kidd, 2009). As a theory, SE has become an increasingly popular framework for the predication
of positive health behaviours – particularly smoking cessation, weight control, and physical activity (PA) participation (Holden, 1992) – and has been readily incorporated into the structure of many SM programs, including CR. Cardiac Rehabilitation provides opportunities to develop SE when participants: (a) engage and accomplish each of the exercise training sessions; (b) confidently maintain their dietary recommendations; and/or (c) manage their condition in the face of adverse health challenges. In fact, SE beliefs have been shown to be strongly predictive of CR outcomes (such as exercise frequency, CR attendance, self-reported PA, and aerobic capacity) (Ewart, 1995; Woodgate & Brawley, 2008); convincing the American Association of Cardiovascular and Pulmonary Rehabilitation to acknowledge SE beliefs in their guidelines in relation to the promotion of behaviour change. What is not apparent within the literature, however, is whether patients with CKD gain the same SM strategies and confidence to adequately carry out the self-directed activities provided in CR, and whether these changes translate into positive health behaviours which persist into the future.
Chapter 2

Literature Review

2.1 Chronic Kidney Disease

2.1.1 The Renal System and its Associated Functions

The human body carries out numerous complex activities including the breakdown of material for excretion, the maintenance of compensatory fluctuations (i.e. homeostasis), as well as the preservation of fluid and molecular balance. Central to these processes is the function of the renal system in regulating the complexity of these interactions. Within the process of human metabolism, catabolic processes generate waste products that require elimination from the body. The kidneys, which are two filtering organs located retro-peritoneally just below the rib cage, function to remove the accumulated by-products and help prevent damage to the body from the excess build-up of these substances – i.e. excretory function. In addition to this utility, the renal system also plays an imperative role in the maintenance of chemical balance via the secretion and degradation of enzymes and hormones – i.e. endocrine function. Through the release of these molecules, the body is able to manage a variety of multi-faceted interactions and keeps the system within a normal functioning range. Furthermore, the renal system maintains the body’s fluid volume and electrolyte balance, which control the amount of water and chemical products excreted into the urine. This maintenance of fluid and electrolyte balance (e.g. potassium and magnesium levels) is imperative to sustaining global systemic functions, which rely on the filtering capacity of the kidneys and its associated structures.
The functional unit of the renal system where filtration occurs is called the parenchyma (i.e. nephron). Each kidney contains about one million nephrons that are composed of a network of capillaries (i.e. glomerulus) – through which components of plasma (i.e. water and solutes) are filtered – and tubules – which play a role in the subsequent secretion and reabsorption of serum molecules and electrolytes. During the process of filtration, the size and structure of the glomerular basement membrane helps to monitor the amount of water and small serum molecules excreted into the tubules, in addition to providing a barrier against the elimination of larger blood substances (i.e. proteins) into the urine. As plasma is moved through the renal system, the rate of substance clearance over a unit of time (known as the glomerular filtration rate [GFR]) can be used to assess the global function of the kidneys (Chmielewski, 2003). Clinically, this measurement involves a laboratory blood test that quantifies a specific molecule called creatinine. Creatinine is a breakdown product of muscles that is normally cleared from the blood, by the kidneys, and released into the urine. If the filtering capacity of the renal system is impaired, the level of serum creatinine may potentially elevate indicating renal dysfunction. In normal functioning kidneys, the GFR is between 90-130 mL/min/1.73m² (Kidney Disease: Improving Global Outcomes [KDIGO], 2013b), which naturally decreases by approximately 8 mL/min/1.73m² per decade after the age of 40 (Greenberg & Cheung, 2005). Any deviation from this biological deterioration may suggest functional and/or structural damage to the kidneys. Contributing diseases such as diabetes mellitus (DM) and HTN can accelerate the decline in GFR above normal ranges, in addition to peripheral disruptions to the system – such as chemical toxins or systemic shock to the body. If the nephrons become non-functional by such conditions or external disturbances, the decline in GFR may result in a clinical manifestation known as CKD.
2.1.2 Diagnostic Criteria for Chronic Kidney Disease

Chronic Kidney Disease is a heterogeneous disorder characterized by any disturbance to the structure and/or function of the renal system. Disruptions to the system include (but are not limited to) drug toxicity, metabolic and endocrine complications, CV consequences, infections, and frailty (Hailpern, Melamed, Cohen, & Hostetter, 2007; James et al., 2009, 2010; Wilhelm-Leen, Hall, Tamura, & Chertow, 2009). As a condition with several aetiologies, diagnosis of CKD is quite complex and can be assigned based on a broad range of abnormalities. When establishing diagnosis within clinical practice, CKD is determined according to the presence of:

(a) one or more clinical markers of structural damage; and/or (b) a decreased level of excretory function, for a period of 3 months or more (KDIGO, 2013b).

Damage to the kidneys can occur within the parenchyma, large renal blood vessels, or collecting systems, and is most often inferred from clinical indicators rather than direct examination of the renal tissue (KDIGO, 2013b). The markers of structural damage often provide a clue to the likely site of damage within the kidneys and, in association with other clinical findings, the cause of CKD. According to the Kidney Disease: Improving Global Outcomes (KDIGO) clinical practice guidelines (CPGs), markers of renal damage include:

- Proteinuria (i.e. albuminuria);
- Urine sediment abnormalities (e.g. red blood cell casts in proliferative glomerulonephritis);
- Renal tubular disorders (e.g. nephrogenic diabetes insipidus);
- Inferred pathological abnormalities (e.g. vascular diseases); and
Of these indicators, proteinuria is the most frequently identified marker within clinical practice due to its ease of detection and its suggestive role in the pathogenesis of CKD progression (Remuzzi, Benigni, & Remuzzi, 2006). This marker refers to the presence of increased amounts of serum protein detected in urine dipstick testing, with plasma albumin (i.e. albuminuria) being the principal component found among those with CKD (KDIGO, 2013b). Furthermore, findings from recent epidemiologic data suggest a strong graded relationship between the quantity of urine protein detected and the risk of CKD incidence and progression (KDIGO, 2013b). Irrespective of clinical markers of structural damage, CKD can also be diagnosed based on a decreased level of excretory function.

As stated earlier, glomerular filtration is one of the key functions of the kidneys and is widely accepted as the best indicator of renal function. Within clinical practice, GFR is estimated based on the level of serum creatinine measured in blood tests; adjusted for age, sex, ethnic origin, and body surface area. According to nephrology guidelines, a GFR less than 60 mL/min/1.73 m\(^2\) is indicative of CKD (with or without structural damage) and a value less than 15 mL/min/1.73m\(^2\) is representative of complete renal failure (also referred to as ESRD) (Table 1) (KDIGO, 2013b). When GFR is less than 60 mL/min/1.73 m\(^2\) (without evidence of structural abnormalities), a loss of 50% of the normal adult level of kidney function is evident; which consequently leads to numerous systemic complications (KDIGO, 2013b). These consequences include anemia, acidosis, hyperphosphatemia, and hypoalbuminemia; all of which worsen with declining GFR. The incidence of decreased excretory function can be attributed to either: (a) risk factors which increase the odds of CKD or (b) related diseases or conditions which are associated with causing or contributing to a decline in GFR.
Table 1: Classification of chronic kidney disease based on glomerular filtration rate (GFR)

<table>
<thead>
<tr>
<th>Stage</th>
<th>Description</th>
<th>GFR (mL/min/1.73 m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Normal or high GFR</td>
<td>≥90</td>
</tr>
<tr>
<td>2</td>
<td>Mildly decreased GFR</td>
<td>60-89</td>
</tr>
<tr>
<td>3a</td>
<td>Mildly to moderately decreased GFR</td>
<td>45-59</td>
</tr>
<tr>
<td>3b</td>
<td>Moderately to severely decreased GFR</td>
<td>30-44</td>
</tr>
<tr>
<td>4</td>
<td>Severely decreased GFR</td>
<td>15-29</td>
</tr>
<tr>
<td>5</td>
<td>Complete kidney failure</td>
<td>&lt;15</td>
</tr>
</tbody>
</table>

**NOTE:** In the absence of markers indicating structural damage, neither stage 1 nor stage 2 fulfill the criteria for CKD. Modified from KDIGO (2013b).

### 2.1.3 Epidemiology of Chronic Kidney Disease

In Canada, the prevalence of CKD has been on the rise over the last few decades; with an estimated 2.9 million adults (or roughly 12.5% of the population) currently affected by this condition (Arora et al., 2013). Within clinical practice, certain sociodemographic and clinical factors have been implicated as susceptibility or initiation risks predisposing individuals to CKD. These include advanced age, family history of CKD, low income/education, being of a certain ethnicity (e.g. American Indian, Asian, Pacific Islander), or low birth weight (Levey & Coresh, 2012; NKF, 2002). Among these characteristics, being Hispanic or Latino (of any race), of African-American decent, or over the age of 70 have been correlated with the greatest risk for developing CKD (12.5%, 12.3%, and 9.2%, respectively) (NKF, 2002).

Alongside these risks, exposure to certain diseases or conditions can also lead to and/or cause CKD; including hormone imbalances, peripheral neuropathies, or cardiac complications (Jha et al., 2013; Levey & Coresh, 2012; McAlister et al., 2012; Smith et al., 2006). Within developed countries, having HTN, DM, or CVD are primarily associated with the elevated incidence of CKD among the general population (U.S. Renal Data System [USRDS], 2009). Specifically, the presence of CVD is the most widespread condition seen among renal cohorts –
with an estimated prevalence upwards of 40%; in addition to being the most deleterious – with CVDs responsible for greater than 50% of premature deaths within the ESRD population (Gansevoort et al., 2013; Hakin & Lazarus, 1989; Hunsicker et al., 1997; Locatelli, Manzoni, & Marcelli, 1996; Shlipak et al., 2005).

2.2 Cardiovascular Disease

2.2.1 Risk of Cardiovascular Disease Among the Chronic Kidney Disease Population

According to the World Heart Federation (2012), CVD (also referred to as heart disease) is defined as any disorder affecting the heart and systemic blood vessels (throughout the body and brain); including:

- *Cardiac-related CVDs* (e.g. MI, CHD, heart failure);
- *Brain-related CVDs* (cerebrovascular disease, hemorrhagic stroke, ischemic stroke);

and

- *Circulatory system-related CVDs* (deep vein thrombosis, hypertensive heart disease, peripheral artery disease, pulmonary embolism) (World Heart Federation, 2012).

In 2009, the Public Health Agency of Canada documented that nine out of ten Canadians over the age of 20 had at least one risk factor for the development of CVD and more than 1.3 million Canadians were affected by these conditions (Public Health Agency of Canada, 2009). Among those with CKD (of any stage), this statistic is heightened to even greater proportions than the general population. In a study conducted by Go and colleagues (2004), those with Stages 1-2 CKD (estimated GFR [eGFR] ≥60 mL/min/1.73 m²) had an age-standardized rate of CV events of 2.11 per 100 persons/year (Go, Chertow, Fan, McCulloch, & Hsu, 2004). After adjustment for
differences in sociodemographic characteristics and the presence or absence of: prior CVD, prior hospitalizations, DM, HTN, dyslipidemia, lung or liver disease, cancer, a serum albumin level of 3.5 g per deciliter or less, dementia, proteinuria, and the initiation of dialysis during follow-up, the risk of an adverse event increased by 43% in those with Stage 3a CKD (eGFR = 45-59 mL/min/1.73 m²) and 343% among those with Stage 5 CKD (eGFR <15 mL/min/1.73 m²) (Go et al., 2004). This elevated risk of cardiac-related complications subsequently translates into an increased risk of CV mortality, which is approximately 10 to 30 times higher in CKD cohorts than the general population after stratification for age, race, and gender (NKF, 2002; Vlagopolous & Sarnak, 2005). Specifically, deaths from CVD account for nearly 50% of all-cause mortality among those with Stage 5 CKD; which is not surprising given their increased risk of CV events (Vlagopolous & Sarnak, 2005). Although individuals with complete renal failure (i.e. Stage 5 CKD) are at the highest risk of CV consequences, prospective data suggests that most individuals affected by CKD do not reach this stage as they are more likely die prior to the onset of ESRD (Keith, Nichols, Gullion, Brown, & Smith, 2004). According to Keith and colleagues (2004), the rate of developing complete renal failure over a 5-year period is 1.1%, 1.3%, and 19.9% among Stages 2-4 renal cohorts (eGFR = 15-89 mL/min/1.73 m²), respectively; whereas the associated all-cause mortality rates in these groups are 19.5%, 24.3%, and 45.7% (Keith et al., 2004).

Furthermore, supportive data from the Hypertension Detection and Follow-Up Program demonstrates that only 19% of all renal deaths are attributable to ESRD verses 58% from CVDs (Shulman et al., 1989). Because of the greater risk for CV mortality among those with Stages 2-4 CKD, the prevention and mitigation of CVDs is imperative to control within these stages.
The increased probability of CVD in those with CKD is due, in part, to a higher prevalence of conditions that are recognized as risk factors for CVD among the general population (“traditional” CVD risk factors); alongside hemodynamic and metabolic factors characteristic of CKD (“CKD-related” CVD risk factors) (NKF, 2002) (Table 2). “Traditional” determinants of cardiac-related events are those defined in the Framingham Heart Study and used by healthcare practitioners to estimate the 10-year risk of hard cardiac end points among the general population (McPherson, Frohlich, Fodor, & Genest, 2006; Wilson et al., 1998). Within this definition factors include (but are not limited to) dyslipidemia, DM, HTN, and physical inactivity; all of which are prevalent in persons with CKD (NKF, 2002; Uhlig, Levey, & Sarnak, 2003; Vlagopoulos & Sarnak, 2005). “Chronic Kidney Disease-related” risks are those factors that increase in frequency as GFR declines and include the presence of anemia, oxidative stress, inflammation, and abnormal calcium metabolism (Sarnak et al., 2003; NKF, 2002). Although these renal-specific components elevate the risk for CVD, the prevalence of these factors only increases as a function of GFR decline. Seeing as CKD can occur due to structural damage to the kidneys, without a concomitant decrease in GFR, the focus of research has concentrated on the “traditional” CVD risk factor profile as compared to the “CKD-related” CVD risk factors.
Table 2: Traditional verses chronic kidney disease (CKD)-related factors related to an increased risk for cardiovascular disease (CVD)

<table>
<thead>
<tr>
<th>Traditional CVD Risk Factors</th>
<th>CKD-Related CVD Risk Factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-modifiable</td>
<td>• Type (diagnosis) of CKD</td>
</tr>
<tr>
<td>• Older age</td>
<td>• Decreased glomerular filtration rate</td>
</tr>
<tr>
<td>• Male sex</td>
<td>• Proteinuria</td>
</tr>
<tr>
<td>• White race</td>
<td>• Renin-angiotensin system activity</td>
</tr>
<tr>
<td>• Family history of CVD</td>
<td>• Extra-cellular fluid volume overload</td>
</tr>
<tr>
<td>Modifiable</td>
<td>• Abnormal calcium and phosphorus metabolism</td>
</tr>
<tr>
<td>• Hypertension</td>
<td>• Dyslipidemia</td>
</tr>
<tr>
<td>• Elevated low-density lipoprotein cholesterol</td>
<td>• Anemia</td>
</tr>
<tr>
<td>• Decreased high-density lipoprotein cholesterol</td>
<td>• Malnutrition</td>
</tr>
<tr>
<td>• Diabetes mellitus</td>
<td>• Inflammation</td>
</tr>
<tr>
<td>• Tobacco use</td>
<td>• Infection</td>
</tr>
<tr>
<td>• Physical inactivity</td>
<td>• Thrombogenic factors</td>
</tr>
<tr>
<td>• Psychosocial stress</td>
<td>• Oxidative stress</td>
</tr>
<tr>
<td>• Type (diagnosis) of CKD</td>
<td>• Elevated homocysteine</td>
</tr>
<tr>
<td>• Decreased glomerular filtration rate</td>
<td>• Uremic toxins</td>
</tr>
</tbody>
</table>

Modified from NKF (2002).

2.2.2 Traditional Cardiovascular Disease Risk Factors

“Traditional” CVD risk factors have been identified within the general population through prospective cohort studies, most notably the Framingham Heart Study. This long-term, on-going study has identified four modifiable CVD risk factors (smoking, DM, dyslipidemia, and HTN) that are present in over 50% of individuals with established CVD (Canto & Iskandrian, 2003). Of these factors, poor glucose control, abnormal lipid profiles, and elevated blood pressure (BP) play a significant role in the progression of heart disease and incidence of CV mortality in the general population; alongside those with CKD. Among individuals with CKD (eGFR <60 mL/min/1.73 m²), lipid disorders are common in 94.7% of this population; as are arterial HTN and DM, occurring in 89.3% and 37.4% respectively (Völler et al., 2014). Not only are these risk factors
widespread among the renal population, but the concomitant presence of CKD and either condition are also associated with an increased incidence of CVD among Stages 3-4 renal patients (eGFR = 15-45 mL/min/1.73 m²). Within the Atherosclerosis Risk in Communities Study, the relative risk (RR) of CVD was: 3.06 (95% CI: 2.01-4.67) for those with DM and CKD, 2.02 (95% CI: 1.27-3.22) for those with HTN and CKD, and 1.50 (95% CI: 1.25-1.71) and 0.78 (95% CI: 0.62-1.01) for each standard deviation of total cholesterol and high-density cholesterol alongside CKD respectively (Munter, He, Hamm, Loria, & Whelton, 2005). Given the high risk for CVD among persons with CKD, the identification and control of “traditional” risk factors has had a substantial impact on the development of heart disease in this population. Within the following sections, the influence and consequences of each of these factors will be compared and contrasted between the CVD and CKD populations.

2.2.2.1 Diabetes Mellitus

Diabetes Mellitus describes a metabolic disorder that is characterized by elevated serum glucose levels – alongside disturbances in carbohydrate, fat, and protein metabolism – resulting from defects in insulin production, utilization, or both (World Health Organization [WHO], 1999). This state of hyperglycemia consequently leads to structural and/or functional damages of systemic organs, blood vessels, and nerves; all of which increase the risk for CVD and subsequent death. Specifically, the incidence of CV mortality has increased among diabetics, with prevalence rates reaching almost 65% within this cohort (Geiss, Herman, & Smith, 1995). Furthermore, optimal control of diabetes is imperative to achieve as the latest recommendations from the United States (U.S.) National Cholesterol Education Program (NCEP) have designated its presence as a CVD equivalent, meaning that a diagnosis of DM confers the same level of risk of developing a major coronary event as that of established CHD (Expert Panel on Detection,
Consequently, the American Heart Association (AHA) has designated DM an important condition to monitor within clinical practice, especially among cohorts who are at increased risk of developing CVD; such as those with CKD (Grundy et al., 1999).

Globally, DM is reported as the most common cause of CKD – affecting upwards of 44% of all renal cohorts (Tonelli et al., 2006). Data from the 2005-2009 Canadian Health Measures Survey estimated the national prevalence of DM among adults with CKD (Arora, 2013). In those with Stages 1-2 CKD, DM was present in 10.8% of the population; which nearly doubled among those with Stages 3-5 CKD (eGFR <59 mL/min/1.73 m^2) (i.e. 23.4%) (Arora, 2013). The concomitant presence of hyperglycemia and CKD is not only common among persons with CKD, but appears to be synergistically lethal resulting in adverse CV complications and mortality. Within a subgroup of 1 million U.S. elderly Medicare patients, the prevalence of atherosclerotic vascular disease and congestive heart failure was significantly higher in patients with concomitant CKD and elevated serum glucose (49.1% and 52.3%, respectively; \( p < 0.0001 \)) compared to those with neither underlying condition (14.1% and 8.6%, respectively; \( p < 0.0001 \)) (Foley et al., 2005). The presence of these negative consequences further translated into an increased incidence of CV mortality; where the risk of death from cardiac-related complications was increased by 56% in those with diabetic CKD compared to those with normal urinary albumin and serum glucose levels (Foley et al., 2005). To mitigate the risk of adverse CV consequences among diabetic CKD populations, CPGs recommend monitoring elevated glycated hemoglobin (HbA1c) levels – a measure of serum glucose bound to an oxygen carrier. According to the Kidney Disease Outcomes Quality Initiative (KDOQI) guidelines, reducing HbA1c to approximately 7.0% can prevent or delay the progression of microvascular complications of DM in those with CKD (NKF, 2012) (Table 3).
2.2.2.2 Dyslipidemia

Dyslipidemia refers to an abnormality in serum lipid or lipoprotein levels. Clinically, it is manifested by either: high total cholesterol (TC), elevated low-density lipoprotein cholesterol (LDL-C), low high-density lipoprotein cholesterol (HDL-C), high TC/HDL-C ratio, or increased triglycerides (TGs); as characterized in blood laboratory measurements (Steinhagen-Thiessen et al., 2008; Wyszynski et al., 2005). Given the varying degree of expression, the exact level at which dyslipidemia is deemed to be a major CVD risk factor is directly dependent on an individual’s global risk profile – calculated by the Framingham Risk Score. This risk engine provides an estimate of the 10-year probability of a non-fatal MI or coronary death based on age, TC level, smoking status, HDL-C level, and systolic BP (SBP) (McPherson et al., 2006). Among those at elevated risk for cardiac-related complications are individuals with: (a) TC levels >7.21 mmol/L; and (b) HDL-C levels <1.04 mmol/L (McPherson et al., 2006). This long-term risk is further heightened to hazardous levels among those with: (a) DM and over the age of 40 or prevalence of DM for more than 15 years and over the age of 30; (b) documented silent or clinically apparent CVD; (c) microvascular complications of DM; (d) high risk HTN, and/or (e) CKD (Baigent, Burbury, & Wheeler, 2000; Genest et al., 2009).

Abnormal serum lipid or lipoprotein levels are extensive in those affected by CKD, and contribute to CV morbidity and mortality in all renal cohorts (Crook et al., 2003). The major determinants of dyslipidemia in CKD populations can be attributed to reductions in excretory function, the presence of DM, severity of proteinuria, and nutritional status (Kasiske, 1998). Among those with ESRD, a cross-sectional study sought to determine the relationship of abnormal lipid levels with eGFR and proteinuria (Sarnak et al., 2002). After adjustment for age, gender, and the presence of DM, decreased eGFR was positively associated with HDL-C, but not
associated with TC or LDL-C (Sarnak et al., 2002). Furthermore, increased proteinuria was positively associated with total serum cholesterol and LDL-C, and inversely associated with HDL-C (Sarnak et al., 2002). In patients with Stages 2-4 CKD, however, the level of renal dysfunction associated with abnormal lipid profiles has not been consistent or well defined (Kasiske, 1998). Among earlier studies investigating the presence of dyslipidemia in this cohort, the majority of investigations reported the prevalence of increased TG and LDL-C levels, and decreased HDL-C levels (Attman & Alaupovic, 1991; Arnadottir, Thysell, & Nilsson-Ehle, 1996; Grützmacher, März, Peschke, Gross, & Schoeppe, 1988). Since these evaluations, it has been identified that high LDL-C is the lipoprotein associated with the greatest reduction in eGFR; as well as the greatest risk for adverse CV events in this renal cohort. In a longitudinal study conducted by Tonelli and colleagues (2013), 836,060 adults from the Alberta Kidney Disease Network (with at least one measurement of fasting LDL-C, eGFR, and proteinuria) were followed for a mean of 48 months (Tonelli et al., 2013). Findings from this investigation suggested that elevated LDL-C levels were associated with an increase in hospitalization for MI; with incidence rates highest among persons with the lowest eGFR (15-59 mL/min/1.73 m²) (Tonelli et al., 2013). Moreover, the unadjusted rate of MI among those with Stages 3-4 CKD elevated as LDL-C levels increased (7.8 [95% CI: 7.1-8.4], 7.6 [6.8-8.5], 8.8 [7.6-10.2], and 9.9 [7.7-12.6] per 1000 patient-years for LDL-C categories 2.60-3.39, 3.40-4.09, 4.10-4.89, and ≥ 4.90 mmol/L; respectively) (Tonelli et al., 2013). As a result, the KDIGO has developed CPGs for “Lipid Management in CKD” which recommend a target LDL-C value less than 2.6 mmol/L among those with CKD (KDIGO Lipid Work Group, 2013a) (Table 3). Reducing LDL-C to this range can reduce the rate of mortality from MI by a significant amount among Stages 3-4 CKD patients (hazard ratio [Hazard] = 0.93 [95% CI: 0.82-1.04]) compared to lipid categories greater than 2.6
mmol/L in this cohort (HazR = 1.22 [95% CI: 1.06-1.39], 1.68 [1.42-1.99], and 2.06 [1.59-2.67]; for LDL-C categories 3.40-4.09 mmol/L, 4.10-4.89 mmol/L, and ≥4.90 mmol/L respectively) (Tonelli et al., 2013).

2.2.2.3 Hypertension

Hypertension is characterized as chronically elevated BP that results in pathological changes in many organ systems, and frequently leads to MI, stroke, and peripheral artery disease (i.e. CVDs), alongside renal impairment (Stone, Arthur, & Suskin, 2009). According to the 2005 Canadian Community Health Survey, there has been a 70% increase in the incidence of HTN since 1994/1995 (Statistics Canada, 1995, 2006). In 2005, 5.7 million Canadians had been diagnosed with systemic HTN and just over 5 million were on pharmacological therapy for this condition (Campbell et al., 2009). This statistic causes concern for our society in that an elevated BP is the single most common cause of disability in industrialized cities, and consequently leads to an increase in mortality rates (Chobanian et al., 2003). Not surprisingly then, HTN has been identified as one of the most common CVD risk factors to monitor within clinical practice; with increased prevalence seen among those with advanced age, obesity, and CKD.

Within the renal literature, an estimated 70-80% of all patients with CKD have HTN; with increased prevalence as eGFR declines (Buckalew et al., 1996; Coresh et al., 2001). Specifically, for every 10 mL/min/1.73 m² decrease in eGFR the prevalence of HTN significantly increases (Buckalew et al., 1996); with frequencies greater than 95% in those with an eGFR below 20 mL/min/1.73 m² (Buckalew et al., 1996; Rao, Qiu, Wang, & Bakris, 2008; Vlagopoulos & Sarnak, 2005). Consequently, the risk for development of CVD and cardiac-related complications has increased among hypertensive CKD patients as compared to their sex- and CKD-matched partners. Within a study conducted by Kokubo and colleagues (2009), hypertensive male and
female subjects with CKD (eGFR <60 mL/min/1.73 m²) demonstrated increased risks for CVD based on multivariable adjusted hazard ratios (Kokubo et al., 2009). Compared to those with optimal BP ranges and concomitant CKD, the risk of cardiac-related complications was 5 and 2 times greater among hypertensive male and female CKD participants; respectively (Kokubo et al., 2009). Moreover, the incidence of CV consequences increases by 23% with each 21 mL/min/1.73 m² decrease in eGFR (Ravera et al., 2009). The cause-and-contribution relationship between elevated BP and renal dysfunction consequently makes patients with CKD an ideal cohort to receive treatment for HTN in the hopes of preventing adverse CV-related events.

According to the KDIGO CPGs for the “Management of BP in CKD”, a target of <130/80 mmHg (for those with DM) or <140/90 mmHg (for non-diabetic populations) is recommended for those with CKD in order to reduce the negative impact of this “traditional” risk factor in this population (KDIGO, 2012) (Table 3).

While the burden of each “traditional” risk factor (i.e. DM, dyslipidemia, and HTN) on CVD incidence and mortality varies considerably depending on individual characteristics – such as the degree of CKD, age, and sex – the early mitigation of these components has the potential to reverse, delay, or prevent the progression of CKD and its associated cardiac-related complications within all stages of renal disease. Increasing evidence, accrued over the past few decades, has indicated that the majority of modifiable CVD risk factors are amendable by lifestyle choices, social changes, or drug regiments. Among these strategies, those that target modifying lifestyle choices through adherence to positive health behaviours are one of the most effective in improving long-term CV health and kidney function.
Table 3: Comparison of recommendations for the management of traditional risk factors among cardiovascular and chronic kidney disease (CKD) populations

<table>
<thead>
<tr>
<th>Risk factor</th>
<th>Governing association/society</th>
<th>Recommendation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diabetes mellitus</td>
<td>Canadian Diabetes Association(^\gamma)</td>
<td>• HbA1c ≤ 6.5% (for those with diabetes)</td>
</tr>
<tr>
<td></td>
<td>KDOQI CPG for Diabetes and CKD(^*)</td>
<td>• HbA1c 7.1-8.5% (non-diabetic populations)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• HbA1c ~7% (diabetic and non-diabetic populations)</td>
</tr>
<tr>
<td>Dyslipidemia</td>
<td>Canadian Cardiovascular Society(^\phi)</td>
<td>• LDL-C levels &lt;2.5 mmol/L and TC/HDL-C ratio &lt;4.0 mmol/L</td>
</tr>
<tr>
<td></td>
<td>KDIGO CPG for Lipid Management in CKD(^\alpha)</td>
<td>• LDL-C levels &lt;2.6 mmol/L</td>
</tr>
<tr>
<td>Hypertension</td>
<td>Canadian Hypertension Society(^\Delta)</td>
<td>• &lt;130/80 mmHg (for those with diabetes)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• &lt;140/90 mmHg (non-diabetic populations, including CKD cohorts)</td>
</tr>
<tr>
<td></td>
<td>KDIGO CPG for the Management of BP in CKD(^\delta)</td>
<td>• &lt;130/80 mmHg (for those with diabetes)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• &lt;140/90 mmHg (non-diabetic populations)</td>
</tr>
</tbody>
</table>

CPG = Clinical practice guideline; HbA1c = Glycated hemoglobin; HDL-C = High-density lipoprotein cholesterol; KDIGO = Kidney Disease: Improving Global Outcomes; KDOQI = Kidney Disease Outcomes Quality Initiative; LDL-C = Low-density lipoprotein cholesterol; TC = Total cholesterol. **NOTE**: \(^\gamma\) Canadian Diabetes Association (CDA) Clinical Practice Guidelines Expert Committee, 2013; \(^*\) NKF, 2012; \(^\phi\) Anderson et al., 2013; \(^\alpha\) KDIGO, 2013a; \(^\Delta\) Dasgupta et al., 2014; \(^\delta\) KDIGO, 2012.
2.2.3 Modification of the Cardiovascular Disease Risk Factor Profile Through Adherence to Health Behaviours

Globally, a significant proportion of the mortality from the leading causes of death (i.e. non-communicable diseases including CVDs, cancers, respiratory diseases, and DM) are due to harmful health behaviours (Conner & Norman, 1996). In the Handbook of Health Behavior Research, Gochman (1998) defines health behaviours as “… overt behavior patterns, actions, and habits that relate to health maintenance, to health restoration, and to health improvement” (Gochman, 1998). Behaviours within this definition include: utilizing medical services (e.g. physician visits, vaccinations, screening), engaging in self-directed activities (e.g. nutritious diet, regular exercise, not smoking), and adhering to medical treatments (e.g. psychosocial programs, antihypertensive regimens). Of these activities, participating in self-directed health behaviours is the most significant to undertake among those with chronic diseases, as active participation in one’s healthcare plan is paramount to health maintenance. Specifically, research into the primary reasons for mortality in North America have shown that engaging in self-directed activities (including smoking cessation, nutritional dietary choice, and physical exercise) can result in improved quality of life (QOL) by delaying the onset of chronic conditions (Conner & Norman, 2005). Based on this evidence, the World Health Organization has shown that up to 80% of heart disease, stroke, and type 2 diabetes could be prevented by eliminating the major harmful lifestyle choices in the general population (including tobacco use, unhealthy diet, physical inactivity, and the use of alcohol) (Ezzati, Lopez, Rodgers, Vander Hoorn, & Murray, 2002). These results are mirrored among those with concomitant CKD, where an improved nutritional status and increase in physical activity levels can, specifically, reduce the prevalence of CVDs in this population.
Within the following sections, the impact of each treatment will be compared and contrasted between the CVD and CKD populations.

2.2.3.1 Nutrition and Diet Modification

Healthy nutrition plays an essential role in reducing the risk of adverse events among those with heart disease. The positive effects of dietary modification can be explained in part by their multi-factorial influence on modifiable CVD risk factors and subsequent lifestyle choices. Specifically, it has been demonstrated that nutritional interventions help to manage poor glucose control, dyslipidemia, and elevated BP; all of which, if successfully treated, can aid in improving ones CV health and renal function (Stone et al., 2009).

Controversy remains with regard to the dietary recommendations specific for treating and managing DM among those with CVD. The majority of studies have focused on targeting low carbohydrate intakes (i.e. <130 g/day) as they demonstrate improvements in serum glucose and HbA1c levels (Kirk et al., 2008; O’Neill, Westman, & Bernstein, 2003). However, restricting carbohydrates to this target may not provide adequate nutrients (i.e. fibre, vitamins, minerals) or glucose for the central nervous system to function. This can have negative consequences on body composition and the ability to adhere to exercise recommendations due to low muscle glycogen (Rodriguez, DiMarco, & Langley, 2009). Consequently, it is generally easier for those with DM to choose high fibre foods – which, for the most part, have a low glycemic index – and focus on an overall healthy eating pattern. Potential diets include ones with up to 45% of calories from fat, emphasizing monounsaturated fat sources and reducing saturated fat (e.g. Mediterranean diet). These diets have demonstrated improvements in insulin sensitivity and lipid levels – particularly TG and HDL levels – and may therefore be effective for individuals with hyperglycemia and dyslipidemia (Brehm et al., 2009; Due et al., 2008; Grundy, Abate, & Chandalia, 2002).
Among those with abnormal lipid levels, the intake of fatty acids is directly related to an increase in CVD risk within the general population (Expert Panel on Detection, 2001). Specifically, saturated fatty acids (SFAs) raise LDL-C, which are the major cholesterol-carrying particle within plasma (Expert Panel on Detection, 2001). In order to reduce the incidence of adverse CV complications, the most effective strategy is to restrict the consumption of high fat foods to less than 7% for “high risk” groups (Expert Panel on Detection, 2001). Foods low in SFAs include those with omega-3 fatty acids, vitamins C and E, folate, L-arginine, and isoflavones (Brown & Hu, 2001; Davignon & Ganz, 2004; Hennig, Toborek, & McLain, 2001; West, 2001). Furthermore, higher intake of nutrient-dense, fiber-rich, plant-based foods tend to lower LDL-C levels as well (Brown & Hu, 2001; Davignon & Ganz, 2004; Hennig et al., 2001; West, 2001). Collectively, the limitation of fatty acids in dietary interventions has been shown to significantly reduce CV mortality by upwards of 40-68% (de Lorgeril et al., 1999; Haskell et al., 1994; Singh et al., 1992, 2002). Moreover, the effect of nutritional interventions on the prevention of cardiac-related complications can be understood through its role in the management of HTN.

Traditionally, the main strategies for lowering systemic BP have included exercise, weight loss, and moderate consumption of alcohol (Stone et al., 2009). Emergent evidence, however, has demonstrated that certain dietary patterns can be as effective at lowering BP as these conventional regiments; specifically the management of daily sodium intake. An overview of observational data obtained from population studies suggest that a reduction in sodium intake to 100 mmol/day has been associated with a mean difference in SBP of 10 mmHg and a 50% reduction in diastolic BP (DBP) (i.e. 5 mmHg) (Law, Frost, C. D., & Wald, 1991). Even a moderated decrease in dietary consumption of salt to 50 mmol/day can lead to a 50% reduction in
the incidence of individuals on antihypertensive therapies, a 22% reduction in stroke mortality, and a 16% reduction in CHD mortality (WHO, 2003). Consequently, a reduced salt intake of less than 120 mmol/day has been recommended to ameliorate the risk for CV-related complications among the general population. In order to reach this target level, those affected by heart disease need to adhere to strict nutritional programs such as the Dietary Approaches to Stop Hypertension (DASH) diet. This diet consists of a nutrient-dense pattern rich in fruits and vegetables, whole grains, lean meats, fish, nuts, legumes, low fat dairy, lean protein sources, moderate total fat intake (~25% of total kcals), and low SFA intake (~7%) (Appel et al., 1997). Compared to a typical American dietary pattern, this nutritional program is associated with significant improvements in both systolic (11 mmHg) and diastolic (6 mmHg) BP in persons with CVD after only two weeks (Appel et al., 1997). Such a reduction in arterial pressure is clinically relevant and has been shown to reduce CV morbidity by greater than 5%, stroke by 8-14%, and all-cause mortality by 4% within normotensive populations (Braith & Stewart, 2006; Heiwe & Jacobson, 2011). The reductions in BP associated with dietary modifications can further be understood in those affected by CKD; a population with extensive evidence of this CVD risk factor.

The management of disease progression in CKD is aimed at addressing a multiplicity of factors known to be associated with renal dysfunction. Optimal nutrition is one element to target in order to slow the complications associated with CKD, alongside the adverse CV-related events associated with this condition. It has been supported that those affected by CKD have a decreased ability to excrete high sodium loads and, hence, have salt-sensitive HTN (KDIGO, 2013b). High sodium concentrations increase BP and proteinuria, induce glomerular hyper-filtration, and blunt the regulation of long-term blood volume (i.e. the renin-angiotensin-aldosterone system).
(KDIGO, 2013b). Current recommendations for those with Stages 3-4 CKD suggest limiting salt intake to 2000-3000 mg/day, which has been shown to significantly reduce BP in hypertensive renal cohorts (Filipowicz & Beddhu, 2013). Yu and colleagues (2012) demonstrated that a short-term reduction of sodium intake to 2300 mg/day is associated with clinically significant reductions in systolic (-11.1 mmHg vs. -5.0 mmHg; \( p = 0.022 \)) and diastolic (-9.4 mmHg vs. -2.1 mmHg; \( p = 0.009 \)) BP compared to renal cohorts without salt restrictions (Yu, Luying, Haiyan, & Xiaomei, 2012). Furthermore, salt restrictions to this level can decrease the number of hypertensive patients from 23.8% to 8.2% among those with metabolic syndrome (Hoffman & Cubeddu, 2007).

Alongside preventing and treating HTN through salt restrictions, supplementary dietary modifications have also been shown to improve renal outcomes; specifically through the reduction of energy and fat intake. High sugar and SFA intake (such as those in processed and red meats, refined grains, sweets, and desserts) are associated with greater odds of microalbuminuria (OR = 2.17; 95% CI: 1.18-3.66) and rapid GFR decline of 3 mL/min/1.73 m\(^2\) per year or greater (OR = 1.77; 95% CI: 1.03-3.03) (Lin & Curhan, 2011). By consuming a DASH diet low in fat and high in energy, the consequent odds of microalbuminuria are reduced significantly (OR = 0.77; 95% CI: 0.44-1.44); alongside a decrease in the risk of rapid GFR decline (OR = 0.55; 95% CI: 0.38-0.80) (Lin & Curhan, 2011). The improvements in HTN and excretory function associated with dietary modifications can also be achieved through the engagement in structured PA (i.e. exercise).
2.2.3.2 Participation in Mixed Exercise Training

Physical inactivity and the pursuit of a sedentary lifestyle are arguably the most important and, without a doubt, the most prevalent causes of cardiac-related CVDs. Among Canadian adults aged 20-79, roughly 68% of men and 69% of women are sedentary during their waking hours; representing a total average daily inactivity period of 575 minutes (9.6 hours) for men and 585 minutes (9.8 hours) for women (Colley, Garriguet, Janssen, Craig, Clarke, & Tremblay, 2011). In order to improve such statistics and mitigate the consequences associated with physical inactivity, it has been suggested that adults partake in ‘structured PA’ (known as exercise) to ensure they are meeting the recommended level of activity. According to the Canadian Physical Activity Guidelines for Adults 18-64 years, it is suggested that individuals accumulate at least 150 minutes of moderate- to vigorous-intensity aerobic PA per week, in bouts of 10 minutes or more (Canadian Society for Exercise Physiology [CSEP], 2011). In addition to CV activities, these guidelines also recommend performing muscle and bone strengthening activities using major muscle groups, at least 2 days per week (CSEP, 2011). This minimal level of engagement impacts an individuals’ ability to sustain positive health-related outcomes and overall well being; in addition to maintaining muscular strength in order to preserve one’s ability to continue independent living. Furthermore, engagement in organized PA also prevents and mitigates many of the “traditional” CVD risk factors including elevated BP, abnormal lipid concentrations, and glucose intolerance (Thompson, 2003). Extensive research evidence has supported these findings, and quantified the benefits associated with participating in exercise among both the CVD and CKD populations.
In terms of the impact exercise has on those with HTN, at least 44 randomized control trials (RCTs) have studied the effect of mixed exercise training (i.e. aerobic and resistance) on this clinical manifestation (Fagard, 2001). In a meta-analysis conducted by Fagard and colleagues (2001), the average reduction in systolic and diastolic BP was 3.4 mmHg and 2.4 mm Hg, respectively, for a cohort of 2,674 normotensive and hypertensive participants (Fagard, 2001). Baseline BP, however, was an important determinant of the exercise effect. Average systolic and diastolic BPs decreased by 2.6 mmHg and 1.8 mm Hg in normotensive subjects, while hypertensive subjects demonstrated reductions of 7.4 mmHg and 5.8 mm Hg; respectively (Fagard, 2001). While this study evaluated the impact of mixed exercise training (EXT) on increased BP, attention to other lifestyle factors and risks have also been investigated. In a meta-analysis of 52 trials, Leon and colleagues (2001) assessed the impact of EXT on those with abnormal lipid profiles (Leon & Sanchez, 2001). Collectively, the data demonstrated an average increase in HDL-C levels of 4.6% and reductions in TG and LDL-C concentrations of 3.7% and 5.0%, respectively, after >12 weeks of training in 4,700 subjects (Leon & Sanchez, 2001). Engagement in aerobic and resistance EXT has also shown to reduce insulin resistance, glucose intolerance, and postprandial hyperglycemia (Thompson et al., 2001). A review of 9 trials examining the effect of mixed EXT in 337 patients with type 2 diabetes reported an average reduction of HbA1c of 0.5-1% (Thompson et al., 2001). Furthermore, the Diabetes Prevention Program demonstrated the powerful effect that mixed EXT can exert in preventing the onset of DM in individuals at high risk for this disease (Diabetes Prevention Program Research Group, 2002). Compared with usual care, there was a 58% reduction in the onset of type 2 diabetes over 2.8 years among individuals randomized to an EXT intervention.
Alongside the improvements in “traditional” risk factors, aerobic and resistance EXT can also translate into reduced mortality rates among CVD populations, as corroborated by the most recent and comprehensive meta-analysis of 51 RCTs (Jolliffe et al., 2001). Collectively, the studies included evaluated 8,440 patients who were primarily middle-aged and had experienced one of the following adverse events: sustained a MI, undergone coronary artery bypass grafting or percutaneous transluminal coronary angioplasty, had angina pectoris, or had coronary artery disease identified by angiography (Jolliffe et al., 2001). Supervised EXT in these programs was generally between 2-6 months in duration, followed by unsupervised exercise by the participant. Results were analyzed according to whether the EXT alone, or in combination with psychosocial and/or educational interventions (i.e. comprehensive program), had an impact on mortality rates. Upon statistical analysis, all-cause mortality was reduced by 27% ($p <0.05$) within the exercise-only interventions, alongside a 31% reduction in the incidence of death ($p <0.05$), compared to those in the comprehensive programs (Jolliffe et al., 2001). Despite the improvements associated with engaging in aerobic and resistance training, a large proportion of the general population still remains sedentary; with activity levels even lower among those with additional co-morbidities, such as CKD.

Among those with CKD, renal patients have been shown to be more sedentary than individuals of the general population (Johansen et al., 2000; Kouidi et al., 1998). In an observational cohort study of 44 individuals with CKD (eGFR: 42 ± 15 mL/min/1.73 m), only 6.5% of participants were meeting current recommended levels of PA, as measuring by CKD-adjusted accelerometry count thresholds for varying intensity levels (Robinson-Cohen et al., 2013). This low engagement in activity has been attributed, in part, to the co-morbid conditions that lead to CKD (i.e. DM, HTN, MI); alongside muscle weakness and fatigue that develop from
the retention of metabolic waste products, hormonal disturbances, and oxidative stress (Castaneda et al., 2004; Johansen et al., 2000; Kouidi et al., 1998; Pechter et al., 2003; Robinson-Cohen et al., 2009). When looking at the impact of CKD on muscle strength, Roshanravan and colleagues (2013) recently assessed lower extremity function in 385 ambulatory Stages 2–4 CKD patients (Roshanravan et al., 2013). Lower extremity function, as measured by standardized physical tests, was 30-55% worse than expected based on normative data accounting for age, sex, and body size (Roshanravan et al., 2013). Furthermore, decreased function was strongly predictive of subsequent mortality; independent of co-morbidity, obesity, and kidney function. This is supported by analyses conducted by the U.S. Renal Data System Dialysis Morbidity and Mortality Study Wave 2 (USRDS, 2009). Data reported in this investigation suggested that patients who were sedentary at the time of initiation of dialysis showed a 62% greater risk for mortality than non-sedentary patients; adjusted for co-morbidities and factors associated with mortality (O’Hare, Tawney, Bacchetti, & Johansen, 2003; Stack, Molony, Rives, Tyson, & Murthy, 2005). These findings, suggesting that poor levels of physical functioning and PA are apparent in CKD populations, have prompted the use of and recommendation for EXT programs within renal cohorts.

The use of aerobic and resistance EXT within patients with CKD has been reported as the most effective in achieving significant health and fitness outcomes, compared to strength or CV training interventions alone (Heiwe & Jacobson, 2011). Studies have demonstrated that mixed EXT can improve vascular health (e.g. lower systemic BP, improve arterial compliance), reduce inflammation and other adverse biochemical changes, and increase overall aerobic capacity. Current American College of Sports Medicine (ACSM) guidelines recommend that renal populations adhere to the following protocol in order to achieve improvements in their CV health
and renal function: moderate intensity, aerobic exercise (40% to <60% of heart rate [HR] reserve, rating of perceived exertion [RPE] 11-13 on a 6-20 Borg Scale) 3-5 days/week, and resistance training (70-75% of 1-repetition maximum [RM]) 2-3 days/week (American College of Sports Medicine (ACSM) & Pescatello, 2014). Among studies that have used similar protocols within this cohort, resting SBP has been evidenced to decrease by a mean difference of 5.80 mmHg (5 studies, 186 participants; 95% CI: 1.19-0.41, \( p = 0.02 \)) and resting DBP by 2.32 mmHg (11 studies, 419 participants; 95% CI: 0.59-4.05; \( p = 0.009 \)) (Heiwe & Jacobson, 2011). This is of importance as even a small reduction in SBP (i.e. 2 mmHg) among the general population can reduce CHD, stroke, and all-cause mortality by significant levels (Pescatello et al., 2004; Stamler et al., 1989; Whelton, Chin, Xin, & He, 2002). Furthermore, improvements in aerobic capacity and resting HR (HR_{resting}) were also reported by these investigators (Heiwe & Jacobson, 2011). In terms of the maximal amount of oxygen consumed during exercise, mixed CV and resistance EXT significantly improved aerobic capacity by a standardized mean difference of -0.77 when compared to either form of training alone (9 studies, 353 participants: 95% CI -1.06 to -0.48, \( p <0.00001 \)) (Heiwe & Jacobson, 2011). Significant reductions in \( HR_{resting} \) were also observed, where a mean difference of 5 bpm was noticed (3 studies, 104 participants): 95% CI: 2-8; \( p = 0.0005; I^2 = 0\% \) (Heiwe & Jacobson, 2011).

In as much as EXT demonstrates a positive impact on CV health among those with renal dysfunction, CKD is still a “chronic” condition characterized by multiple risk factors that progressively worsen with each stage and cannot be mitigated by training interventions alone. By definition, chronic diseases require persistent care to manage the advancing condition on a daily basis; and thus for feasibility, logistical, and financial reasons, many have come to believe that a substantial proportion of such care must be carried out independently by the patients themselves.
In terms of those with CKD, renal populations must invest a considerable amount of time in not only managing their health through engaging in PA, but also by modifying their diet and lifestyle choices, managing numerous medications, and attending medical appointments. Given the complex nature of the day-to-day activities associated with CKD, it is important that renal patients engage in effective self-management (SM) strategies and behaviours in order to maintain their health.

2.3 The Concept of Self-Management

Within chronic disease literature, the term self-management (SM) refers to “an individual’s ability to manage the symptoms, treatment, physical, psychosocial, and lifestyle changes inherent in living with a chronic condition” (McGowan, 2007). This concept includes gaining the knowledge to care for one’s self and the ability to make treatment-related decisions, monitoring symptoms, setting goals, and developing successful partnerships with healthcare providers (Costantini et al., 2008). Engaging in any of these activities (or behaviours) is paramount to effectively attaining health-related improvements, optimal physical functioning, and improved QOL. Among those with CKD, SM behaviours have been categorized into five interdependent dimensions: communication, partnership in care, self-care activities, medication and/or treatment adherence, and self-advocacy (Curtin et al., 2008).

The first of these dimensions (i.e. communication) is the cornerstone upon which the other features of SM are built on. In order for SM to be feasible and effective, renal patients must be able to effectively report their symptoms, problems, experiences, and concerns to their healthcare teams. In turn, they must also receive information, answers, support, and guidance
based on these conversations (Curtin et al., 2005). This endpoint of concordance is known as partnership in care, and is an interdependent behaviour with communication. Without effective communication, patients are unable to create positive relationships with those on their healthcare teams. Successful partnership includes behaviours related to patients’ pursuit of improved interaction with clinicians, as well as independent and proactive information seeking from sources other than the practitioners – such as articles, books, or health websites. This autonomy makes patients experts in their own healthcare, and provides them with sufficient information to live with their illness and deal with any adverse consequences. Such knowledge assures that renal patients are informed about their condition, and can tailor, modify, and monitor activities relating to the SM of their CKD. This concept of self-directed behaviour is known as self-care, which is the “action” dimension of SM and is based on the premise that the best outcomes of healthcare result when patients are actively involved in their own health maintenance. Self-care entails performing aspects of physical care including such behaviours as tracking treatment progress, monitoring symptoms and side effects, taking recommended prescriptions, and pursuing positive wellness-related activities – such as a diet modification and regular EXT (Curtin et al., 2008). Medication and/or treatment adherence constitutes a critical part of self-care, where clinicians must rely on patients to take their prescriptions as recommended. The interdependence of the various dimensions of SM becomes clear in the context of this component; where, if communication is effective and a working partnership is present, there should be, in turn, a greater likelihood of adherence to medication and treatment recommendations. Moreover, patients who are willing to self-advocate for themselves (i.e. the final dimension of SM) can further improve this level of adherence. The self-advocacy component of SM represents patients’ willingness to act positively in their own self-interest, to make decisions for themselves, to
negotiate with healthcare professionals, and to exercise control over their own care and treatment. Examples of activities relating to this dimension include seeking second opinions, changing doctors, offering suggestions regarding care and treatment, and using treatments other than or in addition to what is suggested by the physician.

Given the complexity and importance of each of these dimensions, SM programs have been developed to incorporate these elements into a structured environment for those with CKD to learn. By definition these services “seek to empower individuals to cope with disease and live better quality lives with fewer restrictions from their illness by developing self-efficacy, which is the level of confidence that an individual has in his or her ability to succeed in dealing with their own chronic disease” (McGowan, 2007). Within the renal literature, engagement in such interventions has demonstrated positive impacts on both renal and CV outcomes.

2.3.1 Use of Self-Management Programs Among Renal Cohorts

Participation in SM programs has been demonstrated to improve health status, disability, and patient-physician communication; in addition to decreasing pain, fatigue, and health-related anxiety among those with chronic conditions (Stone et al., 2009). In terms of those with CKD, interventions that have integrated skills to improve SM have also demonstrated enhanced clinical outcomes such increased renal function and decreased numbers of hospitalization events (Jungers et al., 2001; Roubicek et al., 2000; Stack, 2003). In a study conducted by Chen and colleagues (2011), investigators followed Stages 2-5 CKD patients (eGFR <89 mL/min/1.73 m²) for a period of 12-months and randomized participants into either a SM support (SMS) group or a non-SMS group (Chen et al., 2011). Those in the SMS group received the provision of health-related information, face-to-face SM consultations, telephone-based support, and the aid of a support
group. Health-related knowledge and education comprised of an integrated course involving individualized lectures on renal health, nutrition, lifestyle, nephrotoxin avoidance, dietary principles, and pharmacological regimens. The monthly face-to-face SM meetings consisted of education relating to: (a) understanding and self-managing CKD; (b) diet management to delay disease progression and ultimately the need for renal replacement therapies (RRTs); and (c) types of RRTs. To ensure that knowledge was being transferred and participants were adhering to the SM activities, weekly telephone-based support was also provided. Upon completion of the study, absolute GFR was significantly higher in the SMS group than in the non-SMS group (29.11 ± 20.61 mL/min/1.73 m² vs. 15.72 ± 10.67 mL/min/1.73 m²; \( p < 0.05 \)); suggesting a slowing of renal impairment after the engagement in a SM program (Chen et al., 2011). Hospitalization events were also significantly lower in number for SMS patients (n = 5; 18.50%) compared to those in the non-SMS group (n = 12; 44.47%) (\( p < 0.05 \)).

Based on these findings, it seems important for interventions to target skills pertaining to the engagement in self-care activities among those with CKD. Not only can they enhance the acquisition of SM knowledge and encourage the individual to play an active role in the maintenance of their condition, but can also consequently improve renal and clinical outcomes. Despite the positive role of SM programs in improving and restoring health-related outcomes in renal cohorts, limited interventions are currently being offered to this population. Moreover, investigations that teach disease management skills within their structure rarely assess this outcome within their study designs. In a recent literature review conducted by Bonner and colleagues (2014), investigators synthesized and critically appraised current SM interventions available for those with Stages 1–4 CKD (eGFR ≥15 mL/min/1.73 m²) (Bonner et al., 2014). Each article was evaluated for the assessment of SM outcomes, adherence, knowledge,
progression of renal impairment, health literacy, SE, health-related QOL, and hospitalizations. After a full review of 34 publications, only 5 articles met inclusion criteria; with 3 of them explicitly assessing SM as an outcome (Bonner et al., 2014). A key finding was that poor adherence to SM activities was evident in each of these investigations. Specifically, it has been shown that 33-50% of those with CKD do not adhere to recommended treatments and SM activities (Costantini, 2006). Within qualitative research, adherence to SM behaviours (or the ability to adopt recommended SM behaviours) has been described as multi-factorial and includes factors relating to life contexts and events, socioeconomic, health literacy, cultural-religious, confidence, and emotional issues (Novak, Costantini, Schneider, & Beanlands, 2013). One component of poor adherence that has frequently been demonstrated among chronic disease populations is limited patient confidence (also known as self-efficacy [SE]) (McAuley & Mihalko, 1998). This concept refers to one’s belief in their ability to complete a task or activity, and has been shown to be related to engaging in SM behaviours.

2.4 Self-Efficacy: The Missing Link in Chronic Disease Management

According to social cognitive theory, human behaviour is theorized to be a function of incentives (i.e. reinforcements) and expectancies (Conner & Norman, 2005). Within this framework, three kinds of expectancies have been identified: situation-outcome, action-outcome, and SE. Situation-outcome expectancies refer to beliefs about how different events are connected, and action-outcome expectancies are the belief that a specific behaviour will or will not lead to a given outcome (Conner & Norman, 2005). In terms of SE expectancies, this construct is the belief that a behaviour is or is not within an individual’s control (Conner & Norman, 2005). The collective engagement in these expectancies can be used to understand whether individuals
perform specific behaviours, such as SM activities. Within the context of those with chronic conditions, individuals must believe that: (a) their current lifestyle poses a threat to their health (i.e. situation-outcome expectancy); (b) adopting the new behaviour will reduce the threat to their health (i.e. action-outcome expectancy); and (c) they are capable of performing the behaviour (i.e. SE expectancy) (Conner & Norman, 1996). While each of these expectancies is deemed to be important in the initiation and maintenance of human behaviours, SE beliefs have been identified as one factor predicting the engagement in health behaviours; specifically self-directed activities (Bandura, 1997).

Individuals with a high SE are believed to develop stronger intentions to act, to expend more effort to achieve their goals, and to persist longer in the face of barriers and impediments. By definition, this concept refers to “beliefs in one’s capabilities to organize and execute the courses of action required to produce given attainments” (Bandura, 1997). Thus, if people believe that they can take action to solve a problem instrumentally, they become more inclined to do so and feel more committed to the decision. In terms of performing SM behaviours, Bandura’s SE theory has shown that individual’s beliefs about personal capabilities can significantly predict future health behaviours (Bandura, 1977a, 1977b). These beliefs about personal efficacy develop from cognitive appraisal of information arising from four major sources: performance mastery, vicarious experiences, verbal persuasion, and emotional arousal or physiological feedback (Bandura, 1977a, 1977b) (Figure 1). Performance mastery is the most powerful source for enhancing SE beliefs (Bandura, 1977a, 1977b). This construct provides individuals with observable evidence (i.e. task accomplishment) for the behaviour they are trying to attain or alter. If they are able to continually perform this activity, then repeated success will increase perceived SE. Secondly, vicarious experiences (or modeling) can influence one’s personal beliefs by
comparing and contrasting a situation performed by a similar individual. When individuals are exposed to persons who have similar capabilities to them, the successful performance of a task by a model will provide individuals with the confidence they need to engage in that behaviour themselves. Thirdly, verbal persuasion is the influence of others' suggestions on efficacy beliefs; in particular by those in authority or those who have expert knowledge. For example, if a health educator reassures a patient that they are correctly performing an activity due to their competencies, they are more likely to feel confident to subsequently engage in that activity. Lastly, emotional arousal relates to indicators of energy, strength, and stamina which individuals use as cues to judge their capabilities. If a person experiences no apprehension in a threatening situation, they will feel more capable of mastering an activity or behaviour in that environment. Collectively, these four sources of perceived SE help to increase overall confidence in performing and adhering to an activity (such as a SM behaviour), and are believed to play a crucial role in the determination of health behaviours. Among those with chronic diseases, the implicit association between these factors states that individuals who develop SE, with respect to their ability to carry out SM activities, are more likely to build a stronger belief foundation for long-term maintenance of their health (Schwarzer & Fuchs, 1996). Several studies have quantified the relationship between SE and engaging in SM behaviours (Curtin et al., 2008; Flesher et al., 2011; Lin, Tsai, Lin, Hwang, & Chen, 2013; Lorig et al., 2001).
2.4.1 Self-Efficacy and its Relationship to Chronic Disease Self-Management

Activities pertaining to disease management have been defined as “any positive effort or behaviour individuals engage in in hopes of optimizing their health, preventing complications, controlling symptoms, and/or minimizing the intrusion of the disease into their preferred lifestyles” (Curtin & Mapes, 2001). In all areas of disease management, baseline beliefs that an activity or behaviour will be beneficial to one’s health predict subsequent expectancies; meaning that higher baseline expectations predict higher follow-up expectations. This is evident among a cohort of 831 participants with heart disease, lung disease, stroke, or arthritis who participated in a 6-month Chronic Disease SM Program (CDSMP) (Lorig et al., 2001). This program provided 7 weekly sessions (2.5 hours in duration) to help patients with chronic diseases develop SM skills. The CDSMP content included information regarding: the adoption of exercise programs; use of cognitive symptom management techniques, such as guided relaxation and distraction; nutritional change; fatigue and sleep management; use of medications and community resources; managing...
the emotions of fear, anger and depression; training in communication with health professionals and others; health-related problem-solving; and decision making (Lorig et al., 2001). The implementation of the CDSMP was based on SE theory where the program incorporated modeling and social strategies known to enhance a sense of personal efficacy, and included: guided mastery of skills through weekly action plans and feedback of progress, modeling of SM behaviours and problem solving strategies, reinterpretation of symptoms, social persuasion through group support, and guidance for individual SM efforts. In order to determine whether SE was associated with the uptake and adherence to SM activities, the utilization of health services (i.e. number of emergency room visits, days in hospital) was measured at baseline, 6-months after the program, and 1- and 2-years post the CDSMP. Upon the completion of the CDSMP, reduced use of services at 1 year was associated with higher levels of SE at baseline ($p < 0.0001$), and the greater the 6-month improvement in SE ($p = 0.0203$) the lower the healthcare utilization at 1 year (Lorig et al., 2001). These findings suggest that engagement in a SM program not only significantly improves perceived beliefs regarding one’s capabilities, but also demonstrates that increases in SE correlate with reductions in ambulatory healthcare utilization. This relationship between improved SE beliefs and self-directing behaviours has also been studied among those with CKD.

In order to delay CKD progression and improve QOL, individuals must learn to incorporate treatment recommendations within their daily lives and engage in them with confidence. Renal literature has shown that perceived SE is a correlate of engaging in CKD-specific behaviours (Curtin et al., 2008). In a study conducted by Curtin and colleagues (2008), 174 pre-dialysis patients (i.e. those not on RRT) completed a 49-item questionnaire regarding their level of participation in CKD-specific behaviours (i.e. communication, partnership in care,
self-care activities, medication adherence, and self-advocacy) (Curtin et al., 2008). Together with quantifying their engagement in SM activities, this scale also investigated the concept of perceived SE; specifically querying respondents’ confidence regarding their capacity to execute such activities. Upon statistical analysis, patient age, education, diabetic status, HTN, serum creatinine level, the physical and mental components of the 36-Item Short Form Health Survey questionnaire, and perceived SE were each significantly associated with 1 or more of the SM behaviours (Curtin et al., 2008). Of these variables, however, patients’ perceived SE was a more consistent correlate of SM behaviour than either of the demographic or health characteristics. Upon controlling for patient age, education, diabetic status, HTN, serum creatinine level, and the physical and mental components of the 36-Item Short Form Health Survey questionnaire, SE was positively associated with four of the five CKD-specific SM behaviours (communication [β = 0.132, p = 0.000], partnership in care [β = 0.130, p = 0.000], self-care activities [β = 0.096, p = 0.013], medication adherence [β=0.011, p=0.071]) (Curtin et al., 2008). One limitation of this study, however, was that the quantification of engaging in SM behaviours was based on self-report measurements – i.e. no intervention was provided to study participants. Given this methodological design, the investigators were unable to state the empirical impact SE had on renal patients’ participation in SM activities. In order to understand this relationship better, an intervention-based study would need to be undertaken to measure the changes in confidence as individuals engage in SM activities. To our knowledge, only two investigations in the CKD literature have quantified this outcome (Flesher et al., 2011; Lin et al., 2013); however, neither design incorporated the four sources of SE into their SM interventions, nor targeted the complexity of factors contributing to the aetiology and progression of CKD (i.e. CVD risks). One paradigm, among CVD populations, has been identified which successfully incorporates...
Bandura’s SE theory into a CVD prevention model to provide individuals with the skills they need to successfully manage their condition, adhere to associated treatment recommendations, and perform self-directed activities with confidence.

2.5 The Cardiac Rehabilitation Paradigm

In order to self-manage one’s health and adhere to a prescribed treatment protocols, CVD patients need to be provided with access to supports in goal-setting, action-planning, and problem-solving. The provision of these elements allows individuals to play a major role in the maintenance of their health, and acquire the necessary information and skills needed for the SM of their condition (Stone et al., 2009). According to the literature, the collective adherence and persistence with prescribed exercise, health behaviour interventions, and nutritional therapies is associated with paramount lifestyle changes needed to sustain positive self-directed activities (Stone et al., 2009). Cardiac rehabilitation (CR) is one systematic model that includes these multi-faceted elements within its structure and targets effective behaviour changes among those living with CVD. According to the Canadian Association of Cardiac Rehabilitation (now the Canadian Association of Cardiovascular Prevention and Rehabilitation) this model is defined as:

The enhancement and maintenance of cardiovascular health through individualized programs designed to optimize physical, psychological, social, vocational, and emotional status. This process includes the facilitation and delivery of secondary prevention through risk factor identification and modification in an effort to prevent disease progression and the recurrence of cardiac events. Secondary prevention refers to the sum total of all interventions, physiological and behavioural, designed to favourably modify an
individual’s lifestyle and enhance adherence and compliance with long-term behaviours compatible with minimizing disease progression (Stone et al., 2004).

At its core, the CR paradigm provides individuals with access to:

- Individualized CV health assessment and CVD risk factor determination;
- Health behaviour interventions targeted at changing lifestyle behaviours related to CVD risk (e.g. psychosocial support, dietary modification, mixed EXT);
- CVD risk factor counseling and management (i.e. HTN, dyslipidemia, DM); and
- Patient education programs (i.e. SM and education adherence strategies) (Stone et al., 2009).

Collectively, these elements provide heart disease patients not only with the necessary skills to alleviate or lessen health-related symptoms, reduce disability, and modify multiple CVD risk factors; but additionally offers individuals strategies to cope with emotional distress, improve disease management, and increase SE (Balady et al., 1994). Such tactics have been evidenced to improve both clinical outcomes such as exercise capacity, systemic BP, lipid profile, and mortality rates; alongside impact behavioural outcomes (most notably PA behaviour and SE).

2.5.1 Clinical and Behavioural Benefits Associated With Cardiac Rehabilitation

2.5.1.1 Improved Lifespan Among Individuals Participating in Cardiac Rehabilitation

The CR paradigm has been proven to significantly improve clinical outcomes and reduce mortality related to adverse events among those with heart disease. In a meta-analysis performed by O'Connor and colleagues (1989), 22 RCTs involving 4,554 patients investigated the impact of CR on the incidence of death (O’Connor et al., 1989). Participation in this rehabilitative service
may contribute to a 20% reduction in risk for all-cause mortality, a 22% reduction in risk for CV mortality, and a 25% reduction in risk for fatal events among all participants (O’Connor et al., 1989). When looking at the most recent meta-analysis and review of CR RCTs, this rehabilitative service may reduce the relative risk of cardiac mortality by 26% compared to those undergoing usual CVD care (Taylor et al., 2004). This extension in lifespan can specifically be attributed to CR’s effect on reducing the risk and incidence of CV-related complications. In a study conducted by Sdringola and colleague (2003), those receiving comprehensive CR had a 67% reduction in CV-related events compared to those undergoing dietary-lifestyle (e.g. reduction of fat intake, regular exercise) and pharmacologic lipid treatments (e.g. lipid active drugs to reduce cholesterol to target values) alone (Sdringola et al., 2003). Furthermore, the incidence of adverse cardiac events was reduced by 78% in the CR cohort as compared to those receiving the dietary-lifestyle/pharmacological lipid treatment (Sdringola et al., 2003). The primary reason for these benefits can be traced, in part, to the beneficial effects of CR on CV outcomes and CVD risk factors, including (but not limited to): exercise capacity, glucose control, lipid profile, inflammation, and systemic BP.

2.5.1.2 Improvements in Traditional Cardiovascular Disease Risk Factors Associated with Participating in Cardiac Rehabilitation

One of the key goals and first-line interventions in the attempt to reduce or eliminate the risk of CV-related events is preventing and/or mitigating the risk factors associated with these consequences (e.g. HTN, diabetes, renovascular disease). In order to manage these complications and optimize function (physical, mental, emotional, and cognitive), the adoption of, and adherence to, self-directed behavioural activities is imperative (Stone, 2009). Engagement in a comprehensive risk reduction program, like CR, has been shown to improve numerous CV
outcomes compared to those undergoing usual care alone. Among those participating in this rehabilitative service, reductions in LDL-C (-22%), TGs (-20%), body weight (-4%), intake of dietary fat (-24%), and TC (-40%) and increases in HDL-C (+12%) and exercise capacity (+20%) have all been demonstrated (Gordon & Haskell, 1997). Such improvements correlate with improved mortality rates and QOL for those with CVD risk factors, including diabetics and those with dyslipidemia (Booth, Gordon, Carlson, & Hamilton, 2000; Clark, Hartling, Vandermeer, & McAlister 2005; Clark, Hartling, Vandermeer, Lissel, & McAlister, 2007; Laughlin, 2004; Taylor et al., 2004).

The seminal role of CR in reducing the adverse events associated with DM can be understood through the Steno-2 Studies. These studies were conducted at the Steno Diabetes Centre in Denmark, where 160 patients with DM were randomized to receive either intensive health behaviour interventions plus CVD risk factor modification (i.e. CR) or conventional treatment of CVD risk factors (consistent with the Danish Medical Association recommendations) over a treatment period of 7.8 years (Gæde et al., 2003; Gæde, Lund-Andersen, Parving, & Pedersen, 2008). Upon follow-up, intensive therapy was associated with a lower risk of CV mortality (HzdR = 0.43; 95% CI: 0.19-0.94; \( p = 0.04 \)), a reduction in the development of adverse events (HzdR = 0.41; 95% CI: 0.25-0.67; \( p <0.001 \)), and a decline in the absolute risk for all-cause mortality (Gæde et al., 2003, 2008). In addition to these benefits, the vast majority of investigations into the effects of CR have focused on the changes in blood lipid levels among participants (Taylor et al., 2004). Interest in this area is primarily due to the support for hypercholesterolemia as a CVD factor with the highest percentage of attributable risk in those post-MI (Yusuf et al., 2004). Recently a systematic review and meta-analysis of RCTs was undertaken by Taylor and colleagues (2004) to review the effectiveness of exercise-based CR on
l lipid profiles (Taylor et al., 2004). Based on 48 trials with a total of 8,940 heart disease patients, CR was associated with a significant reduction in TC (weighted mean difference [WMD]: -0.37 mmol/L; 95% CI: -0.63 to -0.11) and TG (WMD: -0.23 mmol/L; 95% CI: -0.39 to -0.07) levels among those participating in this rehabilitative service compared to those undergoing usual care (Taylor et al., 2004). Moreover, for every 1 mmol/L decline in LDL-C there is a concomitant decrease of 21% in terms of CV events after participation in CR (Yusuf, Lonn, & Bosch, 2009). In addition to these clinical improvements, CR participants gain valuable skills in terms of self-managing their condition; which may play a role in ultimately slowing the progression of their disease.

2.5.1.3 Behavioural Benefits Associated With Cardiac Rehabilitation

Central to the efficacy of CR are the health behaviour interventions and risk factor modification strategies utilized within its structure to empower individuals with CVD to take control of their condition and develop effective SM behaviours (Stone et al., 2009). The positive changes in behaviour can be attributed to the behavioural framework in which CR has employed and emphasized within its design (i.e. the Transtheoretical Model of Behaviour Change). The Transtheoretical Model of Behaviour Change is an integrative, biopsychosocial model conceptualizing the process of intentional behaviour change through four core constructs: stages of change, processes of change, decisional balance, and SE (Prochaska & Velicer, 1997). Inherent to its structure is the assumption that individuals do not change their behaviours quickly and decisively; but rather modifications in behaviour, especially habitual activities, occur continuously within a cyclical process. Using this knowledge, CR has been developed to assess an individual's readiness to act on newer healthier behaviour and offers strategies relating to self-monitoring and systematic observation tactics; as well as provides patients with instructions for
the recording and interpretation of their daily activities, in order to identify the factors leading to the adoption of health behaviours. Through the recognition and subsequent self-regulation of these behaviours, patients slowly see improvements in their health status, which, through positive feedback, increase their confidence in self-managing their condition. The mechanism by which confidence is attained in CR can be understood through the sources of SE described by Bandura.

At its core, CR is designed to incorporate each of the four sources of SE; where a sense of *performance mastery* is accomplished as participants engage in EXT sessions, *vicarious experience* or modeling is understood through group education assemblies, *verbal persuasion* is offered by the inter-disciplinary healthcare team, and tactics to deal with *emotional* distress are discussed within psychosocial counseling sessions. Based on these sources, it can be understood that individuals who partake in this rehabilitative service receive the necessary skills to adopt optimistic beliefs and expectancies, which consequently lead to the engagement in SM behaviours. This is demonstrated in a cohort of CR participants who received SE enhancement, problem-solving skills, and relapse prevention strategies with respect to exercise maintenance. By employing this intervention, investigators demonstrated that engagement in a 5-month CR program lead to maintenance of exercise behaviours nine months after the completion of the program (McAuley, Lox, & Duncan, 1993). Exercise behaviour at follow-up was assessed via self-report and consisted of subjects completing a short inventory detailing their exercise participation patterns over the past nine months. Hierarchical multiple regression analyses revealed that improved confidence ($R^2 = 0.112, p < 0.05$) was a significant and unique predictor of exercise maintenance (McAuley *et al.*, 1993).
Based on the above findings, evidence suggests that participation in a CR program has significant benefits relating to reductions in mortality risk, improvements in CV health outcomes, and increased adherence to SM behaviours. Given these positive outcomes, multiple health authorities in North America have stipulated that all those eligible for this rehabilitative service should be referred by their healthcare practitioners. Within Ontario, CR is considered an essential component of cardiac care in that it addresses integration and patient-centered health domains of Cardiac Quality Based Procedures. Based on this standard, CPGs support the need for CR to optimize recovery for patients following a cardiac event (Armstrong, Bogaty, Buller, Dorian, & O’Neill, 2004; Grace et al., 2011a). Unfortunately, only a small minority of eligible individuals are currently being referred to this service (Ades, Waldmann, Polk, & Coflesky, 1992a; Brown, Taylor, Noorani, Stone, & Skidmore, 2003; Daly et al., 2002; Grace et al., 2007, 2008, 2011b; Gravely-Witte et al., 2010; Scott, Lindsay, & Harden, 2003).

2.5.1.4 Low Referral and Enrollment Rates to Cardiac Rehabilitation

In a systematic review conducted by Cortés and colleagues (2006), data from 9 observational studies was available to quantify referral rates among rehabilitation studies employing the use of CR (Cortés & Arthur, 2006). Results from this review demonstrated a variance in accrual rates across investigations – from as low as 10-30% (Barber, Stommel, Kroll, Holmes-Rovner, & McIntosh, 2001; Bittner, Sanderson, Breland, & Green, 1999; Blackburn et al., 2000; Grace et al., 2002; King, Humen, & Teo, 1999; Roblin, Diseker, Orenstein, Wilder, & Eley, 2004; Scott et al., 2003) to as high as more than 60% (Grace, Evindar, Kung, Scholey, & Stewart, 2004; Spencer et al., 2001). Such diverse accrual statistics cause concern for the utilization of this service, as evidence has demonstrated a variance in the proportion of individuals who actually participate in CR.
Globally, enrollment rates to CR have been shown to be less than optimal. In the U.S., only 29.5% of MI survivors have participated in this service (Centers for Disease Control and Prevention, 2003); with even lower rates among eligible individuals in Australia (29%) (Scott et al., 2003) and Japan (21%) (Goto, Itoh, Adachi, Ueshima, & Nohara, 2003). Rates of enrollment in Canada are not well established; however, the most comprehensive understanding of usage rates have been from the province of Ontario where participation was reported as 21.6% (i.e. 9,796 intakes of 45,377 hospital discharge patients) (Cardiac Care Network [CCN] of Ontario, 2002). Furthermore, in a multi-site examination of 1,262 CR outpatients only 529 individuals participated in this health service; representing a non-participation rate of 58.1% (Grace et al, 2009a). Many factors contribute to the decision to use of CR; including distance to facilities, patients’ belief that they could handle their own problems, a lack of time, and no means of transportation to CR as some of the reasons for non-attendance to this rehabilitative service (De Vos et al., 2012).

To better understand the barriers and facilitators associated with CR utilization, Andersen’s expanded Behavioral Model of Health Services Use (1973) has been used to comprehend the types of factors relating to the uptake of this service; specifically predisposing, enabling, and, need characteristics (Table 4) (Andersen & Newman, 1973). Predisposing factors exist prior to the onset of an illness and describe the inclination of an individual to use recommended health services. These include demographic characteristics, social structure, and psychological health status. The relevant predisposing factors shown to affect CR enrollment include sex, age, education level, ethnocultural background, comorbid conditions, history of regular exercise, depression, and anxiety (Grace et al., 2004). Enabling factors are any barriers or facilitators influencing the use of health services, and include economic and environmental
factors related to patient utilization (i.e. living arrangement and distance to the nearest facility).
The CR enabling factors include social support, marital status, benefits and barriers of exercise, perceptions of control, and logistical factors: proximity and time, or work flexibility (Grace et al., 2004). Need factors are the objective and subjective aspects of the decision to use health services, and include physical health status, perceived severity and consequences of illness, and functional abilities. Need factors in CR consist of the patient’s perceived need for this service, and primarily include their perception of disease severity.

Few multi-level studies have assessed the variation in use of any health service, and even fewer studies examining rehabilitation services or CR have been observed. To date, only one investigation has examined the comprehensive list of factors affecting CR enrollment in a broad sample of heart disease patients (Grace et al., 2008). In a multi-site study conducted by Grace and colleagues (2008), 1,490 coronary artery disease patients – nested within 97 Ontario cardiology practices – were surveyed to assess the elements affecting their enrollment to CR (Grace et al., 2008). Among a total of 469 outpatients utilizing this service, enabling factors were central to CR participation; specifically, the strength of physician endorsement ($p = 0.005$), shorter distance to CR ($p = 0.001$), being married ($p = 0.01$), and having fewer perceived CR barriers ($p = 0.03$) (Grace et al., 2008). Whether such factors influence those with other chronic diseases (i.e. respiratory disease, CKD, pulmonary disease) is unknown; despite the fact that CR is available to any individual eligible for the primary or secondary prevention of CV-related complications. It has been demonstrated that a large proportion of CR participants have CKD, yet the specific barriers and facilitators relating to the utilization of this service are unknown among this cohort. Currently, studies have only quantified the prevalence of patients with CKD in CR centres,
and/or the improvements in CVD risk factors and aerobic capacity among CKD populations using this rehabilitative service.

Table 4: Anderson's Behavioural Model of Health Services Use applied to cardiac rehabilitation (CR) enrollment

| Predisposing | • Age  
|              | • Sex  
|              | • Employment status  
|              | • Education level  
|              | • Family income  
|              | • Ethnocultural background  
|              | • Exercise history  
|              | • Other medical conditions that prevent exercise  
|              | • Depressive symptoms  

| Enabling | • Distance and travel time to CR  
|          | • Perceived social support  
|          | • Marital status  
|          | • Living arrangements  
|          | • Exercise benefits and barriers  
|          | • Perceived control  
|          | • Type of referring physician  
|          | • Strength of provider endorsement  
|          | • Number of cardiologist and family physician visits  
|          | • CR barriers  

| Needs | • Risk factors: body mass index, smoking status, family history, hypertension, diabetes, exercise behaviour  
|       | • Disease severity/functional status  
|       | • Perceived need: illness perceptions, timeline acute/chronic or episodic/cyclical, consequences, cure/controllability  

*Modified from Grace et al. (2008).*
2.5.2 Use of Cardiac Rehabilitation Among Renal Populations

Since individuals with CKD carry a high burden of CVD risk factors and co-morbidities, it is vital for renal and cardiac healthcare teams to acknowledge the added benefit of treating these complications in parallel. Nephrology guidelines currently recommend a referral to CR for those on dialysis who are eligible as a management strategy for cardiovascular disease in this population (NKF, 2002); however, this recommendation is not strong and is not regularly used among those not on RRTs. The CKD population represents an ideal cohort who stands to gain significant benefits from a SM-based rehabilitation program, like CR, tailored to providing EXT, self-care counseling, psychosocial support, and SE strategies to manage their condition. Few studies have evaluated: (a) the current prevalence of CKD cohorts among contemporary patients enrolled in CR and (b) the clinical impact of this rehabilitative service among those with CKD. In a retrospective study conducted by Pyka and colleagues (2014), 4,571 CR participants were appraised to determine the relative frequency of renal cohorts attending this service (Pyka et al., 2014). Of the individuals with demographic information required to calculate eGFR (n=499), 35.3% of participants were Stage 1, 45.1% were Stage 2, and 19.6% were Stages 3-5 (Pyka et al., 2014). With respect to their CVD risk factors, those with CKD (i.e. Stages 3-5) had a higher prevalence of hyperlipidemia (77% vs. 62%), HTN (83% vs. 59%), and history of coronary artery disease (64% vs. 50%) compared to the overall CR population (Pyka et al., 2014; Grace, Parsons, Duhamel, Somanader, & Suskin, 2014a). Those participating in this rehabilitative service have also demonstrated clinical improvements comparable to heart disease cohorts after participating in CR.
In terms of the benefits CR imparts on mortality rates, renal function, physical fitness, functional capacity, and emotional/psychological attributes, both ESRD populations and CKD cohorts have shown significant increases in each of these outcomes after completion of this service (Kutner, Zhang, Huang, & Herzog, 2006; Venkataraman, Sanderson, & Bittner, 2005). Among those individuals with complete renal failure (i.e. Stage 5 CKD), adherence to a CR program resulted in a 35% reduced risk for all-cause mortality and a 36% reduced risk for cardiac death compared to those who did not receive the service (Kutner et al., 2006). In patients with acute MI, complicated with Stage 3 CKD (eGFR = 30-59 mL/min/1.73 m²) or severe CKD (i.e. eGFR <30 mL/min/1.73 m²) CKD, participation in a 3-month exercise-based CR program was associated with increased exercise capacity (peak oxygen uptake: 19.3 ± 4.2 mL/min/kg to 21.6 ± 5.2 mL/min/kg; p <0.001) and improved renal function (GFR: 48 ± 12 mL/min/1.73 m² to 53 ± 15 mL/min/1.73 m²; p <0.001) in both cohorts (Takaya et al., 2014). In a recent study conducted by Greenwood and colleagues (2012), investigators reported increases in physical function – as measured by the incremental shuttle walk, timed up and go, sit-to-stand (STS) in 60 seconds, and stair-climb descent tests – among a cohort of pre-dialysis renal patients (i.e. Stages 3-4 CKD) (Greenwood et al., 2012). After completion of a 12-week CR intervention, statistically significant results were found among all outcome measures (p <0.001) (Greenwood et al., 2012). These results are comparable to exercise and functional capacity improvements reported following pulmonary (Hlatky et al., 1989) and cardiac (Goble & Worcester, 1999) rehabilitation programs in CVD populations, and are also consistent with a number of studies evaluating the effect of CR on dialysis patients (Cheema & Singh, 2005; Konstantinidou, Koukouvou, Kouidi, Deligiannis, & Tourkantonis, 2002; Storer, Casaburi, Sawelson, & Kopple, 2005). For those with Stage 5 CKD, significant improvements in aerobic capacity have ranged from 21-43% after completing a
3-6 month CR program (Cheema & Singh, 2005; Konstantinidou et al., 2002; Storer et al., 2005), which is comparable with findings from Greenwood’s study where exercise capacity and functional ability increased by 44% and 21-35%; respectively (Greenwood et al., 2012).

Despite the improved CV health status of those participating in CR, patients with CKD are still less likely to be referred to this rehabilitative service as compared to their age- and sex-matched counterparts (Kutner et al., 2006). As few as 10% of renal cohorts utilize CR, as compared to 23% of the general population (Kutner et al., 2006); however, the factors associated with non-participation have not been documented. Furthermore, it is unsure whether participation in this service provides superior SM skills to the maintenance of CKD, alongside the confidence to adhere to self-directed activities after the completion of CR. Based on the lack of literature pertaining to these topics, our study sought to: (a) quantify the recruitment and enrollment ratios of patients with CKD to CR; (b) describe the predisposing, enabling, and needs factors associated with CR utilization; and (c) understand whether changes in exercise SE are evident upon the completion of this rehabilitative service.
Chapter 3

Methods

Given the exploratory nature of this project, a phase approach was utilized to gain preliminary information regarding: (a) the feasibility of recruiting and enrolling persons with CKD to CR (*Phase I*); and (b) the efficacy of CR in impacting exercise SE among a cohort of individuals with CKD (*Phase II*).

*Phase I* incorporated both a: (a) retrospective chart review – conducted to understand the potential barriers and facilitators associated with the utilization of CR in persons with CKD – and (b) prospective evaluation – to document rates of recruitment, and recruitment and enrollment ratios in a cohort of patients with CKD meeting study inclusion criteria. Inherent to the practicality of conducting a pilot study is the accrual and retention of an adequate number of study participants. Within clinical research literature, recruitment (i.e. accrual) is understood as “the process by which [investigators] find eligible, competent, and compliant research subjects, within fixed time lines and limited budgets, meeting specific study quotas” (Clinical and Translational Science Institute, n.d.). Enrollment (i.e. retention), on the other hand, occurs when an eligible, informed, prospective subject undergoes the initial informed consent process and voluntarily agrees to participate in a research project. This construct follows the process of accrual, and ultimately represents whether a future larger intervention will occur (i.e. is it feasible to recruit the necessary number of study participants). We sought to investigate each of these constructs among a cohort of persons with CKD who were offered enrollment to a CR program. To our knowledge, no previous study has quantified either of these outcomes in persons with
CKD; providing support for the need of this investigation to begin to disseminate and potentially enhance renal clinical care.

Upon successful enrollment of participants to the study and, thus, admission to a CR centre, *Phase II* was conducted to determine whether participation in this rehabilitative service has an impact on exercise SE among persons with CKD. A case series approach was utilized for the pilot study to: (a) obtain evidence supporting the theoretically expected treatment effect; (b) test the sustainability of outcome measures; and (c) generate hypotheses to be tested in future analytical trials (Medical Research Council (MRC): Health Services and Public Health Research Board, 2000). A case series study design is an important and necessary tool within the evaluative stages of a research investigation, especially when the intervention and its associated outcomes have not been reported among a novel cohort. This rationale is supported by the Medical Research Council (2000) who have developed a framework for the sequential series of phases necessary in the evaluation of a complex intervention, such as CR (MRC, 2000).

To assess the impact of CR in altering participants’ exercise SE throughout the course of this rehabilitative service, a repeated measures within-subjects design was used. This analysis involves three or more assessments on the same experimental unit, and allows for the monitoring of participant change over time. Alongside the evaluation of exercise SE, additional secondary outcomes were quantified to understand the global impact of CR on CV health, behaviour change, physical function, and renal outcomes. All outcome measures in *Phase II* (i.e. primary and secondary) were administered within two weeks of initiating CR (i.e. weeks -1 and -2; ‘baseline’), and within two weeks of completing the intervention (i.e. weeks 14-16; ‘discharge’). The primary outcome (i.e. exercise SE) was additionally measured on a monthly basis throughout
the study period (i.e. week 4, 8, and 12). Timing and location of each outcome measure are reported in Appendix A.

3.1 Phase I

3.1.1 Participant Recruitment

A retrospective chart review was employed to determine: (a) the number of patients serviced by the Kingston General Hospital (KGH) Nephrology Program who would meet the clinical eligibility criteria for Phase II and (b) an overall recruitment rate and ratio, and enrollment ratio for this cohort. The latter objective was further used to provide prospective data in order to inform the design of a future RCT. The population screened included individuals with established CKD and who were enrolled as patients within the Nephrology Program at KGH. The Nephrology Program is the only renal service serving the South-Eastern Ontario region, which has a catchment area of 1.10-1.25 million individuals. This multi-disciplinary clinic is staffed by three nephrologists, two advanced practice nurses, a dietitian, a social worker, and a pharmacist. Currently, approximately 700 patients with CKD are followed within the Nephrology Program.

Patient charts were reviewed on a weekly basis between August 27th and December 3rd, 2014 (over a total of 14 weeks). Individual files were retrieved from the clinic reception desk according to the names indicated on the daily appointment schedule. Approximately 60 patients (new and existing) are seen by program staff each week, rendering the recruitment period sufficient to target the entire cohort serviced by the Nephrology Program. A 42-item chart abstraction form was used to obtain necessary data to include or exclude patients from Phase II (Appendix B). The chart abstraction form, developed for this study, was first piloted on 30 charts
to ensure efficient capture of all required data. Data on sociodemographic variables (age, sex, postal code), clinical characteristics (e.g. HTN, obesity, musculoskeletal impairments), and renal outcomes (eGFR) were collected.

3.1.2 Inclusion and Exclusion Criteria

Participants were included in Phase II of the study if they:

a) Were a patient of the Nephrology Program and diagnosed with Stages 3-4 CKD, as per the KDIGO CPGs (KDIGO, 2013b). Aetiology was established by one of the eight nephrologists at KGH;

b) Were over the age of 18; and

c) Had at least one of the following CVD risk factors:

i. Overweight

ii. HTN

iii. Dyslipidemia

iv. Diabetes or pre-diabetes

v. Anemia

Participants were excluded from Phase II of the study if they had:

a) Completed the CR program at Hotel Dieu Hospital (HDH) within the previous 12 months;

b) Cognitive and/or behavioural issues that would limit their participation in exercise testing and/or program training as determined by attending medical staff; or

c) Other CVD co-morbidity, which would limit their exercise tolerance.
An exhaustive list of all inclusion and exclusion criteria is provided in Appendix C. Those who met inclusion criteria and were willing to participate (i.e. provided verbal confirmation of recruitment during their appointment at the Nephrology Program) had a referral form completed by the study nephrologist at KGH (Dr. J. Garland – co-investigator) for referral to the local CR centre and subsequent enrolment to \textit{Phase II (Appendix D)}. Informed consent was received after the referral had been processed by staff at the \textit{Cardiac Rehabilitation Centre (CRC)} at HDH, and participants had completed a graded exercise tolerance test (GXT) with a finding of an aerobic fitness level greater than 3.0 metabolic equivalents (METs). The informed consent form was approved by the Queen’s University Faculty of Health Sciences Research Ethics Board (REH-538-12) (Appendix E).

3.1.3 \textit{Outcome Measures}

3.1.3.1 \textbf{Primary Outcome Measure}

1. \textbf{Recruitment rate, recruitment ratio, and enrollment ratio}: To understand the feasibility of recruiting and enrolling persons with CKD to CR, four quantitative measurements were calculated:

   a) \textit{Recruitment rate} = number of participants recruited $\div$ duration of recruitment period

   b) \textit{Recruitment ratio} = number of participants recruited as a percentage (%) of participants approached

   c) \textit{Enrollment ratio} = number of participants enrolled as a percentage (%) of participants approached
d) *Enrollment-to-recruitment ratio* = number of participants enrolled as a percentage (% of participants recruited

3.1.3.2 Secondary Outcome Measure

1. **Barriers and facilitators to cardiac rehabilitation utilization:** Many factors contribute to the decision to participate in a CR program. Based on Andersen and Newman’s (1973) framework for examining health service utilization, certain patient-level variables were extracted from all patient files to understand the characteristics relating to CR enrollment (Andersen & Newman, 1973). In terms of *predisposing factors*, age was retained from charts and categorized based on: (a) <65 years of age and (b) ≥65 years of age; alongside sex. In terms of *enabling factors*, the distance and time taken to travel from patients’ homes to the CRC at HDH (HDH-CRC) was documented. Distance was quantified to the nearest 0.1 km and time was computed to the nearest minute using the *ArcGIS Online* geographic information system from Esri Canada (2015). Time was further categorized based on travel of: (a) <15 minutes; (b) 15-30 minutes; (c) 31-45 minutes; (d) 46-60 minutes; and (e) >60 minutes. In terms of *needs factors*, five CVD risk factors were extracted from each file (i.e. the presence of DM, HTN, dyslipidemia, obesity, and anemia). These variables were determined by physician notes extracted from the patient charts.
3.1.4 Data Analysis

Data were entered into a password-protected Excel file developed for this study, and imported into IBM SPSS (version 21.0 for Windows) for statistical analysis. Data was analyzed descriptively; including means and standard deviations for continuous data, and frequencies and percentages for categorical data. Continuous data (e.g. distance) were compared using the independent samples t-test, while categorical data (e.g. sex) were compared using the Pearson chi-square test or the Fisher’s Exact test – if there were fewer than 5 patients in one category.

3.2 Phase II

3.2.1 Protocol

The HDH-CRC program is, on average, 16-weeks in length and consists of activity and exercise prescription, supervised exercise classes, dietary counselling, behavioural modification counselling and skills development, lifestyle education, medication reconciliation, and psychosocial and vocational counselling. These services are provided by an inter-professional team consisting of a cardiologist, dietitian, social worker, nurses, and physiotherapists. Prior to the start of the individual’s rehabilitation, participants received a package (approximately 2-4 weeks after recruitment from the KGH Nephrology Program) inviting them to begin the on-site weekly group education sessions (discussed below) and instructing them to undergo routine admission procedures. This latter process includes routine blood work at the HDH internal lab, a GXT in the HDH cardiology department, an on-site 2-hour Screening (Intake) Clinic appointment, and an on-site ‘Recommendation Meeting’.
The Screening Clinic incorporates a one-to-one evaluation and discussion with a CV nurse (30 minutes), cardiologist (30 minutes), and physiotherapist (60 minutes). Each practitioner collects necessary clinical data, via interviews, and targeted physicals to complete a full CVD risk factor profile used to triage participants for short-term exercise risk. All data are entered into the electronic CV patient management system – the Vascular Health Protection Network®. To determine the risk of experiencing an adverse event while participating in EXT, the Risk of Activity Related Events (RARE) Score is used (Lacombe, LaHaye, Hopkins-Rosseel, Ball, & Lau, 2014) (Appendix F). This validated point-based scoring system utilizes resting HR and BP, functional capacity, ejection fraction, ischemic burden, and the presence of arrhythmias to stratify risk. Each of these variables is assigned a value between 0 and 4 points; with the exception of resting HR and BP, which have a maximum value of 2 points. The risk estimate is then calculated by summing the points for each of the 6 individual variables, resulting in a total score between 0 and 20 points. A score of <4 triages the individual into a low risk group – a group at low risk of an adverse event during moderate to vigorous activity or exercise. A receiver operating curve analysis (A = 0.65) validated this cut-off as the most accurate to identify patients who are at low risk, with 99% of low-risk patients being free of an adverse event during follow-up (Lacombe et al., 2014). To quantify an ‘adverse event’, Lacombe and colleagues (2014) used a reporting tool to document any adverse events that occurred while patients attended a 17-week CR program (Lacombe et al., 2014). Adverse events were categorized as major or minor; with the former consisting of death, cardiac arrest, MI, and acute coronary syndrome, while all other adverse events were categorized as minor.
The comprehensive results from the pre-screening tests (i.e. GXT), the Screening Clinic evaluations, their individual CVD risk factor profile, and the triage score are all communicated and explained to the participants one week later at a ‘Recommendation Meeting’; conducted by one of the CRC team members. In addition, this meeting familiarizes participants with the rehabilitation components and goals, and orients them to their individual exercise and activity prescriptions, as well as the exercise logistics to be undertaken both at the HDH-CRC and in the community. Each participant is invited to sign both a consent form to communicate with their associated healthcare professionals and a letter of commitment to the rehabilitation process. One week after the ‘Recommendation Meeting’, participants begin their on-site and community-based EXT sessions. The full rehabilitation process algorithm describing each of these steps is outlined in more detail within Appendix G.

3.2.1.1 Exercise Sessions

Both on-site and community-based mixed EXT sessions (i.e. aerobic, resistance, and flexibility training) were prescribed to all participants. On-site sessions were supervised by a registered nurse and physiotherapists (1:5 clinician:participant ratio) at the HDH-CRC (1.5 hours, 2 days/week for an average of 16 weeks). Community-based exercise sessions were added in week 3 and took place ≥1 time per week following the same 1.5 hour exercise prescription throughout the rehabilitation period (i.e. 16 weeks). Aerobic exercise parameters were prescribed by a registered physiotherapist based on results of the GXT, employing ACSM guidelines (9th edition) (described below) (ACSM & Pescatello, 2014), and then individualized based on the participant’s CVD risk factor profile, triage score, and associated co-morbidities.
Each on-site session began with an 8-12 minute warm-up period; incrementally challenging the CV system, upper extremities, lower extremities, trunk muscles, and balance. A copy of the warm-up is provided in Appendix H. Following the warm-up period, 30 minutes of aerobic training commenced. Training intensities were based on 60-85% of target HR (identified in their GXT – prescription described below) and achieved using a high intensity interval training approach (a repeating pattern of bouts of 2-3 minutes and 30-60 seconds). The aerobic component was partitioned into three, 10 minute individualized rotations of staff-selected aerobic modalities. The training apparatuses included (but were not limited to): treadmill, step ups, arm ergometer, NuStep, rower, elliptical, and stationary cycle. Heart Rate, BP, RPE (0-10 Borg RPE Scale – Appendix I), and symptoms were monitored at 10 minute intervals throughout the aerobic component of the training sessions. Following aerobic training, participants completed 20-30 minutes of resistance training. Training intensities were set at 60-85% of the maximal weight used during a 10-RM test as determined by the physiotherapist (prescription described below). Participants chose any combination of free weights, resistance band work, and/or Universal Gym™ to complete their prescription. Training loads were set based on participant long-term functional goals, but averaged to two sets of 8-13 repetitions for each muscle group. Activities targeted specific muscles of the upper and lower extremities, back, chest, and abdomen. Following resistance training, each exercise session ended with 12-15 minutes of full body stretching.

Community-based exercise sessions were established using the same protocol as participants’ on-site exercise prescription, and took place either at a local fitness facility or in the participants’ home. Participants were asked to monitor their HR and RPE as previously instructed. To promote SM skills, assist with clinician feedback, and to document adherence,
participants were instructed to complete a detailed exercise diary in their personal logbook on a weekly basis (Appendix J). This logbook was used to document the type of aerobic exercise, symptoms, resting HR and RPE, peak HR ($HR_{peak}$) and RPE, and 5 minute cool down HR and RPE.

Finally, in addition, participants were also asked to adhere to a daily PA level of both walking for a total of 30-45 minutes daily (recording resting and peak HR, and RPE for each bout) and ≥10,000 steps/day. Step counts were monitored using the Omron® HJ-720ITCCAN Pocket Pedometer (PC Version). Both the walks and the steps per day were documented by the participant in their logbook on a daily basis (Appendix J).

Prescription of aerobic EXT was based on results from the GXT occurring at the time of routine admission screening. The GXT was a Ramp Protocol with the protocol level selected by the designated cardiologist or physiotherapist (Slow Ramp, Regular Ramp, Fast Ramp or Athletic Ramp) (Appendix K). Prior to initiation of the testing, participants were familiarized with the equipment, prepped with a 12-lead ECG, and received standardized instructions regarding the use of the 0-10 Borg RPE Scale from the certified stress testing technician. The GXT was run and supervised by the technician using a motor-driven treadmill (GE T2100 Treadmill), with results interpreted by a cardiologist. Participants began the GXT at an intensity of 1.7 METs and a steady speed, and progressed in grade every minute as per the relevant protocol. All participants were given strong verbal encouragement to exercise to volitional exhaustion. The ACSM guidelines for test termination were followed to minimize the chance of adverse events from occurring (Appendix L) (ACSM & Pescatello, 2014). The 12-lead ECG was used for continuous monitoring, and post-test risk determination and exercise prescription. Heart Rate and RPE measurements were obtained during the last 5 seconds of every minute, and immediately after the
test (i.e. peak HR and RPE). Based on resting and peak HRs, target HR was determined using the Karvonen method:

$$\text{Target HR} = [(\text{HR}_{\text{peak}} - \text{HR}_{\text{resting}}) \times \% \text{ intensity}] + \text{HR}_{\text{resting}} \quad (\text{Karvonen & Vuorimaa, 1988})$$

Aerobic training intensities were set at 60-85% of target HR.

Prescription of resistance EXT was based on the results of a 10-RM test at the discretion of the physiotherapist, and conducted during the 7th exercise session (week 4) for each respective muscle group included in training. Traditionally, the 1-RM has been the standard for dynamic strength assessments in the general population; however, in patients with CKD, 1-RM testing is thought to be contra-indicated because of the fear of spontaneous avulsion fractures (ACSM & Pescatello, 2014). Resistance training intensity was set at 60-85% of the maximum weight used during the 10-RM. To determine this load, the ACSM testing protocol was followed (ACSM & Pescatello, 2014):

1. The participant warmed-up by completing a number of submaximal repetitions on the respective resistance exercise to determine the 10-RM.
2. The 10-RM was determined within four trials, with rest periods of 3-5 minutes between trials.
3. A registered physiotherapist selected an initial weight that was within the participant’s perceived capacity.
4. Resistance was progressively increased by 2.5 kg (5.5 lb) until the participant could not complete a total of 10 repetitions. All repetitions were performed at the same speed of movement and range of motion to instill consistency between trials.
5. The final weight successfully lifted was recorded as the absolute 10-RM.
3.2.1.2 Education Sessions

Participants were also asked to attend 12 education sessions held at the HDH-CRC over the course of their rehabilitation (i.e. 16 weeks). Topics covered the areas of nutrition (3 sessions), medications, stress management (3 sessions), the anatomy/physiology and function of the heart, circle of support, and exercise and activity (3 sessions). Each session was 1.5 hours in length and taught by a registered healthcare professional (i.e. nurse, dietitian, pharmacist, physiotherapist, and/or social worker). A sample education schedule is provided in Appendix M. Family members were strongly encouraged to attend all educational and counselling sessions.

3.2.2 Outcome Measures

3.2.2.1 Primary Outcome Measure

1. Exercise self-efficacy: The Multidimensional Self-Efficacy for Exercise Scale [MSES] (Appendix N) is a 9-item self-report questionnaire designed to assess the level of confidence individuals have when performing an assigned exercise protocol (Rodgers, Wilson, Hall, Fraser, & Murray, 2008). Items are rated on a 10% increment scale from 0-100%, where 0% = “not at all confident” and 100% = “completely confident”. A total score is determined by calculating the mean value for all items, with a maximum score being 100%. Items can also be analyzed based on the three sub-constructs of SE: (i) task SE; (ii) coping SE; and (iii) scheduling SE. Task SE relates to one’s confidence in performing the elemental aspects of a behaviour, and has been shown to be positively associated with exercise initiation (Rodgers, Hall, Blanchard, McAuley, & Munroe, 2002). Coping SE relates to one’s confidence in performing the task in the face of
barriers, such as “not feeling well”, and has been shown to be positively correlated with the maintenance of exercise (Rodgers et al., 2008). Scheduling SE is one’s confidence in managing the time demands of exercising regularly, and has been shown to be the strongest predictor of exercise persistence (Rodgers et al., 2002; 2008). A total score for each sub-construct is determined by calculating the mean value for all associated items within that category, with a maximum score being 100% (task SE = items 1-3; coping SE = items 4, 5, and 8; scheduling SE = items 6, 7, and 9). Within our study, this questionnaire was administered to participants at five distinct time points: baseline (week -1), throughout the CR program (weeks 4, 8, 12), and at discharge (week 16).

The MSES has been shown to have good psychometric support in the context of CR, alongside good predictive value with respect to subsequent exercise behaviour. In a study of 470 community-based exercises, Cronbach alphas (α) for internal consistency were 0.84 for task SE, 0.81 for coping SE, and 0.85 for scheduling SE (Rodgers et al., 2008). The correlation between task and coping was 0.57, between task and scheduling 0.51, and between coping and scheduling 0.55, revealing discriminant validity (Rodgers et al., 2008). When looking at internal reliability, an acceptable level has been demonstrated for this measure using a pre-post design (baseline: α = 0.79, 0.87, and 0.83 respectively for each construct; end of CR: α = 0.90, 0.71, and 0.88 respectively for each construct) (Rodgers, Murray, Selzler, & Norman, 2013). When looking at the relationship between SE and subsequent exercise behaviour, evidence supports the use of this questionnaire in a CR context. In a sample of 63 CR patients, the MSES was used at: (a) baseline to predict self-reported minutes of moderate activity during CR and (b) the end of rehabilitation to predict self-reported minutes of moderate activity 1-month post CR.
(Rodgers et al., 2013). Collectively, the three constructs of SE explained 11% of the variance in exercise behaviour during rehabilitation ($F(3, 79) = 3.28, p = 0.025, R^2 = 0.11$); however, only task SE emerged as a significant independent predictor (Rodgers et al., 2013). When administered at the end of rehabilitation, the constructs explained 24% of the variance in exercise behaviour 1 month after the conclusion of rehabilitation ($F(3, 61) = 6.41, p = 0.001, R^2 = 0.24$); although, only scheduling SE was a significant independent predictor (Rodgers et al., 2013). To our knowledge, no prior investigation has utilized the MSES among persons with CKD undergoing CR; providing us with the opportunity to test its efficacy within this cohort.

3.2.2.2 Secondary Outcome Measures

1. **Physical activity behaviour:** To understand whether changes in exercise SE were associated with changes in PA behaviour, daily step counts were measured. The Omron® HJ-720ITCCAN Pocket Pedometer (PC Version) was provided to all participants to track their steps each day throughout the 16 weeks of CR. As this device only stores data for 41 days, participants also used their exercise diary (Appendix J) to document their daily values. This logbook was retained at discharge and used to calculate an average daily step count matching the same time period of when exercise SE was measured. Mean values were calculated across a 5-day period, and analysed at: baseline (week -2), throughout the CR program (weeks 4, 8, 12), and at discharge (week 15). A target value of $\geq 10,000$ steps/day was set by program staff at the HDH-CRC.
2. **Self-management behaviours:** A sub-section of the *Life Options CKD Self-Management Survey* (Appendix O) was used to understand participants’ behaviours regarding the SM of their CKD (Curtin *et al.*, 2008). Collectively, this questionnaire consists of 59 items divided into six sub-scales (five relating to SM behaviours, and one associated with perceived SE). The five SM categories are communication with caregivers, partnership in care, self-care, self-advocacy, and medication adherence. A total of 44 items (out of 59) relate to these dimensions; however, only 38 items were utilized within our analysis. Based on previous work using this measure, questions 8-10 and 39-42 were dropped from analysis as these items caused the overall reliability of each SM sub-scale to decrease appreciably (Curtin *et al.*, 2008). Of the remaining items, 8 related to communication with caregivers (α = 0.77), 7 to partnership in care (α = 0.84), 11 to self-care (α = 0.77), 10 to self-advocacy (α = 0.70), and 1 to medication adherence (Curtin *et al.*, 2008). All questions are rated on a 4-point Likert scale; where 1 = never, 2 = a few times, 3 = a lot of the time, and 4 = all the time. A total score for each SM sub-scale was determined by calculating the mean value for all associated items within that category, with a maximum score being 4. Within our study, participants were administered this questionnaire at baseline (week -2) and discharge (week 15).

3. **Physical function:**

   a) **Peak aerobic capacity:** A GXT in the HDH cardiology department was performed to determine participants’ baseline and discharge level of peak aerobic capacity. One of four ramp protocols (Slow Ramp, Regular Ramp, Fast Ramp, or Athletic Ramp) was selected by the cardiologist or physiotherapist designated to perform the test (Appendix K). Prior to initiation of the testing, participants were familiarized with
the equipment, prepped for a 12-lead ECG, and received standardized instructions regarding the use of the 0-10 Borg RPE Scale from the certified stress testing technician. The GXT was run and supervised by the technician using a motor-driven treadmill (GE T2100 Treadmill), with results interpreted by a cardiologist. Participants began the GXT at an intensity of 1.7 METs and a steady speed, and progressed in grade every minute as per the relevant protocol. All participants were given strong verbal encouragement to exercise to volitional exhaustion. The ACSM guidelines for test termination were followed to minimize the chance of adverse events from occurring (Appendix L) (ACSM & Pescatello, 2014). The corresponding MET level at the end of the testing session was noted as per the protocol used. In order to be clinically significant, the Cardiac Care Network has signified a 0.5 MET increase in aerobic capacity as a quality indicator for CR (Grace et al., 2014b). This measurement was administered at baseline (week -2) and discharge (week 14).

b) Lower extremity function: The 30-second chair stand test (30CST) is a self-paced tool designed to assess an individual’s ability to rise from a chair and sit back down, as well as their lower extremity function. Individuals are asked to complete as many full STS repetitions in a 30 second time period, starting from a sitting position in a chair with no armrests. Specific instructions verbalized to individuals are presented in Appendix P. Within our study, the number of complete STS repetitions in 30 seconds was recorded for each participant across three separate trials; with the mean number of repetitions calculated after completion. A 60-second rest period was provided between trials. This measurement was administered at baseline (week -1) and discharge (week 15).
In terms of psychometric properties, the 30CST has been validated as a measure of lower-extremity strength against a one-RM leg press in community-dwelling older adults (Jones, Rikli, & Beam, 1999). A moderate correlation was found with the weight-adjusted leg-press test of lower extremity strength in both elderly men ($r = 0.78$; 95% CI: 0.63-0.88) and women ($r = 0.71$; 95% CI: 0.53-0.84) (Jones et al., 1999). In terms of inter-rater reliability, a sub-sample of 15 participants indicated a coefficient of 0.95 (95% CI: 0.84-0.97) (Jones et al., 1999). Among those with ESRD, both the absolute test–retest reliability (standard error of measurement [SEM]) and minimal detectable change [MDC] (at the 95% confidence interval [MDC$_{95}$]) statistics have been computed (Overend, Anderson, Sawant, Perryman, & Locking-Cusolito, 2010). In a convenience sample of 25 participants recruited from an outpatient dialysis unit, a SEM of 0.9 and a MDC$_{95}$ of 2.6 repetitions were calculated between two trials, one week apart (Overend et al., 2010).

c) **Lower extremity power:** The stair climb test (SCT) is used to assess the ability of an individual to ascend a flight of stairs; as well as their lower extremity power, strength, and balance. The examiner stands with the individual at the base of a well-lit, 10-stair flight of stairs. Individuals are instructed to safely ascend the stairs as fast as they can, using the handrail for safety purposes if needed. Timing begins on the examiners cue of “go” and is terminated when both feet of the individual are on the top step. Within our study, the time to ascend a flight of stairs was recorded for each participant across three separate trials; with the mean time calculated after completion. Time was recorded to the nearest 0.1 second using the Timex® Triathlon
Stopwatch, and a 30 second rest period was provided between trials. This measurement was administered at baseline (week -1) and discharge (week 15).

In terms of psychometric properties, negative correlations have been found between the 9-step SCT and quadriceps/hamstring strength in those with knee osteoarthritis (Maly, Costigan, & Olney, 2006). Lower values (i.e. faster times) on the SCT indicated better performance, whereas higher values on the lower extremity strength test indicated better performance (r = -0.50 and -0.52, respectively) (Maly et al., 2006). In terms of measurement error, a detectable change at 90% confidence and a SEM have been calculated among those with end-stage hip and knee osteoarthritis (Kennedy, Stratford, Wessel, Gollish, & Penney, 2005). In a sample of 21 elderly individuals (mean ± SD: 63.7 ± 10.7 years old), a MDC of 5.5 seconds and a SEM of 2.35 seconds (95% CI: 1.89-3.10) were found (Kennedy et al., 2005).

d) **Functional balance**: Functional balance was measured using the 14-item Berg Balance Scale [BBS] (Berg, Wood-Dauphine, Williams, & Gayton, 1989) (Appendix Q). This instrument is used to assess stability changes in the general population due to aging or disease progression, or to monitor progress in rehabilitation. The focus of the BBS is on functional performance rather than the underlying impairment of poor balance, and is considered the gold standard for the evaluation of balance performance within the elderly (Liston & Brouwer, 1996). Individuals are asked to perform a variety of tasks from maintaining one’s stability in standing, to performing dynamic tasks involving single legged stance, to executing movements with increasing speed; all of which are observed and rated by a trained personnel. The rating of each activity ranges from 0 (“inability to perform”) to 4 (“ability to perform...
the task safely”), with a total possible score of 56. Higher scores indicate greater balance control and are indicative of a lower risk of future falls. Within our study, participants completed this measurement at baseline (week -1) and discharge (week 15).

The BBS has shown good psychometric support when utilized within community dwelling older adults (Berg, Maki, Williams, Holliday, & Wood-Dauphinee, 1992; Donoghue & Stokes, 2009), and individuals with neurological impairments (Leddy, Crowner, B. E., & Earhart, 2011; Scalzo et al., 2009). Among the elderly, inter-rater reliability is extremely high (ICC = 0.97) and good internal consistency is demonstrated (α = 0.77) (Berg et al., 1992). Additionally, the smallest amount of change corresponding to a noticeable adjustment in ability (i.e. minimal detectable change) depends on the initial BBS score within this population. The following MDC95 values are for initial scores of 0-24, 25-34, 35-44, and 45-56 respectively: 4.6, 6.3, 4.9, and 3.3 (Donoghue & Stokes, 2009).

4. Cardiovascular Disease Risk Factor Profile:

   a) Resting arterial blood pressure and heart rate: Blood Pressure and HR were measured using the BpTRU™ system (VSM MedTech Ltd., Vancouver, Canada), an automated office oscillometric device. The participant was seated in a quiet room for no specified period of rest, with the device automatically taking BP measurements at 1- or 2-minute intervals. The first measure was discarded and the next five measures were averaged. This is consistent with the Canadian Hypertension Education Program guidelines on the measurement of arterial BP in office (Daskalopoulou et al., 2015). Measurements were taken at baseline (week -2) and discharge (week 14).
b) **Anthropometrics – height, weight, and waist circumference:** Body weight was measured to the nearest 0.1 kg using the Scale-Tonic Weighing Equipment, and height was measured to the nearest 0.1 cm. These measurements were used to calculate BMI – i.e. body weight (kg) divided by height squared (m²). Waist circumference (cm) was measured using a standard measuring tape during normal expiration at the mid-point of the palpated iliac crest and the palpated lower margin of the ribs. An intra-rater measurement error of 1.56 cm has been calculated in studies of adolescents (Lohman, Roche. & Martorell, 1988). Study measurements were taken at baseline (week -2) and discharge (week 15).

e) **Glucose and lipid profiles – glycated hemoglobin, fasting blood glucose, high-density lipoprotein cholesterol, low-density lipoprotein cholesterol, total cholesterol, total cholesterol/high-density lipoprotein cholesterol, triglycerides:** Blood was drawn between 8am and 10am, following a 14 hour fast, at the HDH internal lab and analyzed for lipid profile, 75 g oral glucose tolerance test (fasting blood glucose), and glycated hemoglobin. This measurement was administered at baseline (week -2) and discharge (week 14).

5. **Kidney function:** Excretory function was quantified by calculating eGFR using serum creatinine values. Serum creatinine was measured by the Unicell DXC800 (manufacturer: Beckman Coulter) with coefficients of variation <3% for serum creatinine of 163 µmol/L or more, and 1% for serum creatinine of 590 µmol/L or more. All serum creatinine values were obtained from the HDH internal lab at baseline (week -2) and discharge (week 14), in order to minimize inter-laboratory variability and misclassification errors. The Cockcroft-Gault formula was used to calculate eGFR:
eGFR (mL/min/1.73 m²) = [(140-age) x weight x 0.85 if female] / (72 x serum creatinine),
adjusted for body-surface area by 1.73 m² / body-surface area

(Cockcroft & Gault, 1976)
Chapter 4

Results

4.1 Phase I: Recruitment

A total of 611 patient charts were reviewed from August 27th to December 3rd, 2014 (i.e. 14 weeks) at the KGH Nephrology Program. Table 5 outlines the demographic and clinical characteristics of the entire cohort screened. Of this population, 56.3% (n=344) of charts were excluded from potential recruitment as they did not meet inclusion criteria. The top three reasons for exclusion were:

1. Estimated GFR values that were either: (a) not indicative of Stages 3-4 CKD (eGFR >59 mL/min/1.73 m² or <15 mL/min/1.73 m²) or (b) were not reported in the clinic files [56.4%, n=187];
2. Permanent use of a mobility aid (e.g. canes or wheelchairs) [8.4%, n=29]; and
3. Cognitive and/or behavioural issues that would limit participation in exercise testing and training (e.g. delirium, schizophrenia, memory loss) [7.3%, n=25].

In addition to these factors, 8.2% (n=28) of charts were excluded as individuals had either neurological conditions (e.g. Parkinson’s, Alzheimer’s, seizure disorder) or visual conditions (e.g. cataracts, macular degeneration, legally blind); which would not permit full participation in CR. A small percentage of files were grouped as ‘other’ (5.5%, n=19) and included individuals with active alcohol abuse, diagnosed developmental delay, morbid obesity (i.e. BMI ≥45 kg/m²), currently institutionalized in a correctional facility, advanced age (i.e. over 89 years of age), unstable angina, or musculoskeletal impairments (e.g. spinal stenosis or rheumatoid arthritis) which would limit the participant's ability to walk sufficient durations. Lastly, 16.0% (n=55) of
charts were not reviewed and characterized as ‘missing’ as these files were either: (a) actively being used (e.g. transcribed) by a clinician at the time of screening or (b) belonged to a patient who was listed to attend their nephrology appointment, however, their visit had been cancelled (without indication on the daily appointment schedule) or they did not show up for their appointment.

Table 5: Demographic and clinical characteristics of the entire cohort

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>All Subjects (n=611)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, mean ± SD (in years)</td>
<td>69.4 ± 13.8</td>
</tr>
<tr>
<td>Male, % (n)</td>
<td>59.6 (364)</td>
</tr>
<tr>
<td><strong>Chronic Kidney Disease Stage</strong></td>
<td></td>
</tr>
<tr>
<td>Stage 1, % (n)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Stage 2, % (n)</td>
<td>0.7 (4)</td>
</tr>
<tr>
<td>Stage 3a, % (n)</td>
<td>2.3 (14)</td>
</tr>
<tr>
<td>Stage 3b, % (n)</td>
<td>13.1 (80)</td>
</tr>
<tr>
<td>Stage 4, % (n)</td>
<td>44.8 (274)</td>
</tr>
<tr>
<td>Stage 5, % (n)</td>
<td>27.3 (167)</td>
</tr>
<tr>
<td>Not reported, % (n)</td>
<td>11.8 (72)</td>
</tr>
<tr>
<td><strong>Cardiovascular Disease Risk Factors</strong></td>
<td></td>
</tr>
<tr>
<td>Hypertension, % (n)</td>
<td>60.1 (367)</td>
</tr>
<tr>
<td>Diabetes, % (n)</td>
<td>47.1 (288)</td>
</tr>
<tr>
<td>Dyslipidemia, % (n)</td>
<td>13.1 (80)</td>
</tr>
<tr>
<td>Anemia, % (n)</td>
<td>3.9 (24)</td>
</tr>
<tr>
<td>Obesity, % (n)</td>
<td>3.4 (21)</td>
</tr>
</tbody>
</table>

Of the remaining charts, 267 met the inclusion criteria. Of these eligible candidates, 115 (43.1%) individuals were not seen by the research associate due to the fast-paced nature of the clinic. Within the Nephrology Program, all patients are seen by four separate clinicians (nephrologist, nurse, dietitian, and social worker), in addition to having scheduled blood work, making interaction with potential participants challenging in this context. The remaining 152
eligible candidates were approached, with 79.2% (n=123) not being interested in the study and 19.1% (n=29) being left an information package (i.e. interested). Demographic information – categorized according to patient-level factors – is presented in Table 6 for both cohorts.

Of those approached, the two cohorts (i.e., interested and not interested) were relatively similar in terms of age; however, a slightly greater prevalence of males was noticed among the cohort interested in *Phase II* of the study (i.e. 69.0% vs. 61.0%). Upon sub-group analysis, it was demonstrated that those not interested in the CR program were primarily over the age of 64 (i.e. <65 years of age: 24.4% [n=30]; ≥65 years of age: 75.6% [n=93]); with similar proportions in the cohort left an information package (i.e. interested). Additional differences were observed among the ‘enabling’ and ‘needs’ factors. Of those not interested, the primary reason for declining offer to CR was distance (73.2%, n=90). Over 65% of individuals were commuting greater than an hour to their nephrology appointments (i.e. as far as Brockville in the east and Picton in the west), and could not commit to the twice-weekly on-site exercise sessions. Of those interested in the study, most lived within a 20 km commute of the HDH-CRC; with the majority within a 15 minute travel time. In terms of their risk factor profiles, those left an information package had a lower prevalence of CVD risks – with none of them being anemic. There was a slightly higher incidence of obesity (3.4% vs. 2.4%; respectively) in those interested; however, this was only seen in one individual out of the entire cohort.
Table 6: Patient-level factors and recruitment to cardiac rehabilitation (CR)

<table>
<thead>
<tr>
<th></th>
<th>Population approached (N=152)</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Not interested (N=123)</td>
<td>Interested (N=29)</td>
<td>Statistical Significance</td>
</tr>
<tr>
<td>*<em>Predisposing factors</em> **</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age, mean ± SD (years)</td>
<td>69.3 ± 13.8</td>
<td>70.2 ± 11.3</td>
<td>*p = 0.745</td>
</tr>
<tr>
<td>&lt;65 years of age, % (n)</td>
<td>24.4 (30)</td>
<td>24.1 (7)</td>
<td>*p = 0.977</td>
</tr>
<tr>
<td>≥65 years of age, % (n)</td>
<td>75.6 (93)</td>
<td>75.9 (22)</td>
<td></td>
</tr>
<tr>
<td>Male, % (n)</td>
<td>61.0 (75)</td>
<td>69.0 (20)</td>
<td>*p = 0.424</td>
</tr>
<tr>
<td>*<em>Enabling factors</em> **</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Distance to CR, mean ± SD (km)</td>
<td>70.2 ± 38.1</td>
<td>20.5 ± 31.9</td>
<td>*p &lt;0.001</td>
</tr>
<tr>
<td>Travel time to CR, mean ± SD (mins)</td>
<td>53.6 ± 26.1</td>
<td>20.3 ± 23.7</td>
<td>*p &lt;0.001</td>
</tr>
<tr>
<td>&lt;15 mins, % (n)</td>
<td>10.6 (13)</td>
<td>48.3 (14)</td>
<td></td>
</tr>
<tr>
<td>15-30 mins, % (n)</td>
<td>10.6 (13)</td>
<td>20.7 (6)</td>
<td></td>
</tr>
<tr>
<td>31-45 mins, % (n)</td>
<td>6.5 (8)</td>
<td>3.4 (1)</td>
<td>N/A</td>
</tr>
<tr>
<td>46-60 mins, % (n)</td>
<td>26.8 (33)</td>
<td>3.4 (1)</td>
<td></td>
</tr>
<tr>
<td>&gt;60 mins, % (n)</td>
<td>42.3 (52)</td>
<td>10.3 (3)</td>
<td></td>
</tr>
<tr>
<td>Missing, % (n)</td>
<td>3.3 (4)</td>
<td>13.8 (4)</td>
<td></td>
</tr>
<tr>
<td>*<em>Need factors</em> **</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hypertension, % (n)</td>
<td>68.3 (84)</td>
<td>55.2 (16)</td>
<td>*p = 0.179</td>
</tr>
<tr>
<td>Diabetes, % (n)</td>
<td>50.4 (62)</td>
<td>44.8 (13)</td>
<td>*p = 0.589</td>
</tr>
<tr>
<td>High total cholesterol, % (n)</td>
<td>18.7 (23)</td>
<td>10.3 (3)</td>
<td>*p = 0.412</td>
</tr>
<tr>
<td>Obese, % (n)</td>
<td>2.4 (3)</td>
<td>3.4 (1)</td>
<td>*p = 0.575</td>
</tr>
<tr>
<td>Anemia, % (n)</td>
<td>3.3 (4)</td>
<td>0 (0)</td>
<td>*p = 1.000</td>
</tr>
</tbody>
</table>

* Predisposing factors* exist prior to the onset of an illness and include demographic characteristics, social structure, and psychological health status. **Enabling factors** are any barriers or facilitators influencing the use of health services, and include economic and environmental factors related to patient utilization. Need factors are the objective and subjective aspects of the decision to use health services, and include physical health status, perceived severity and consequences of illness, and functional abilities (Johnson, Weinert, & Richardson, 1998).
Among individuals who were left information packages regarding *Phase II* of the study (n=29), 7 patients provided verbal consent to be referred to the HDH-CRC. This resulted in a recruitment ratio of 4.6% ([7 individuals recruited / 152 individuals approached] x 100%); at a rate of 0.5 participants/week. Upon contact from CRC staff, only 3 individuals were enrolled in the study. This equated to an enrollment ratio of 2.0% ([3 individuals enrolled / 152 individuals approached] x 100%) and an enrollment-to-recruitment ratio of 42.9% ([3 individuals enrolled / 7 individuals recruited] x 100%). Of the 4 individuals lost to attrition, the reasons for non-participation were:

a) Change in study design (i.e. originally we were recruiting participants for a control group, which one individual wanted to be a part of) (n=1);

b) No longer interested (n=1); and

c) Decline in health status (n=2).

### 4.2 Phase II: Case Series

The following sections will present clinical results from each of the three participants (Participant 1: Mr. A, Participant 2: Ms. B, and Participant 3: Mr. C) who were enrolled in and graduated from the HDH-CRC program between December 5th, 2014 and May 28th, 2015. The data is presented in terms of baseline (i.e. weeks -1 and -2) and discharge (i.e. weeks 14-16) values for all secondary outcomes (PA and SM behaviours, physical function, CVD risk profile, kidney function); in addition to repeated measures for the primary outcome (exercise SE). Where applicable, findings are compared to either:
a) HDH-CRC standard targets;

b) Age- and sex-predicted norms; or

c) Minimal clinically important differences, SEM, or MDC$_{95}$ for the standardized outcome measures.

Target values and/or clinically significant change scores in outcome measures are presented in Table 7.

Table 7: Outcome measure target values and/or clinically significant change scores

<table>
<thead>
<tr>
<th>Study Variable</th>
<th>Clinically Significant Change Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak aerobic capacity</td>
<td>Δ of 0.5 MET</td>
</tr>
<tr>
<td>30-second chair stand test</td>
<td>MDC$_{95}$ = 2.6 repetitions</td>
</tr>
<tr>
<td>Stair climb test</td>
<td>MDC$_{95}$ = 5.5 seconds; SEM = 2.35 seconds</td>
</tr>
<tr>
<td>Berg balance scale</td>
<td>MDC$_{95}$ = 4.6, 6.3, 4.9, and 3.3 for initial scores of 0-24, 25-34, 35-44, and 45-56; respectively</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Study Variable</th>
<th>Target Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Daily step count</td>
<td>≥10,000 steps/day</td>
</tr>
<tr>
<td>Body mass index</td>
<td>20-25 kg/m$^2$</td>
</tr>
<tr>
<td>Waist circumference</td>
<td>&lt;94 cm for males, and &lt;80 cm for females; SEM: 1.56 cm</td>
</tr>
<tr>
<td>Resting blood pressure</td>
<td>&lt;130/80 mmHg for diabetics; &lt;140/90 for non-diabetics</td>
</tr>
<tr>
<td>Glycated hemoglobin</td>
<td>~ 7.0%</td>
</tr>
<tr>
<td>Fasting blood sugar</td>
<td>4-6 mmol/L</td>
</tr>
<tr>
<td>Total cholesterol</td>
<td>&lt;4.5 mmol/L</td>
</tr>
<tr>
<td>High-density lipoprotein cholesterol</td>
<td>≥1.0 mmol/L</td>
</tr>
<tr>
<td>Total cholesterol/high-density lipoprotein cholesterol</td>
<td>&lt;4.0 mmol/L</td>
</tr>
<tr>
<td>Low-density lipoprotein cholesterol</td>
<td>&lt;2.6 mmol/L</td>
</tr>
<tr>
<td>Triglycerides</td>
<td>&lt;1.7 mmol/L</td>
</tr>
</tbody>
</table>

MDC$_{95}$ = Minimal detectable changes at the 95% confidence interval; SEM = Standard error of measurement.
4.2.1 Participant 1: Mr. A

4.2.1.1 Demographic Characteristics

Mr. A is a 74-year-old male with Stage 4 CKD (baseline eGFR = 24.0 mL/min/1.73 m$^2$). He was admitted to the HDH-CRC on December 3rd, 2014 for his initial Screening Clinic visit and began on-site EXT sessions on a twice-weekly basis starting December 16th, 2014 (Tuesday/Thursday schedule). Table 8 outlines his demographic characteristics.

Prior to beginning the CR intervention, Mr. A demonstrated prevalence of two non-modifiable CVD risk factors (i.e. male sex and advanced age), alongside three modifiable CVD risk factors. He presented with impaired glucose tolerance (i.e. pre-diabetes), HTN (based on diabetic reference values), and dyslipidemia (characterized as high TC and LDL-C levels, in his case). He was also a reformed smoker, who smoked a ¼ pack per day for 25 years.

Table 8: Demographic characteristics of Mr. A at baseline

<table>
<thead>
<tr>
<th>Demographics</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>74.0</td>
</tr>
<tr>
<td>Sex (M/F)</td>
<td>M</td>
</tr>
<tr>
<td>Race</td>
<td>African American</td>
</tr>
<tr>
<td>Marital status</td>
<td>Married</td>
</tr>
<tr>
<td>Occupational status</td>
<td>Retired</td>
</tr>
<tr>
<td>Medications</td>
<td>Beta-blocker, calcium channel blocker, nitrate, diuretic</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CVD Risk Factors</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Diabetic status</td>
<td>Impaired glucose tolerance</td>
</tr>
<tr>
<td>Hypertensive? (Y/N)</td>
<td>Y</td>
</tr>
<tr>
<td>Dyslipidemia? (Y/N)</td>
<td>Y</td>
</tr>
<tr>
<td>Sedentary lifestyle? (Y/N)</td>
<td>N</td>
</tr>
<tr>
<td>Obese? (Y/N)</td>
<td>N</td>
</tr>
<tr>
<td>Smoking status</td>
<td>Reformed smoker</td>
</tr>
</tbody>
</table>

M = Male; F = Female; Y = Yes; N = No. Note: obesity was determined based on the following classification: BMI 18.5-24.9 = normal weight; BMI 25.0-29.9 = overweight; BMI 30.0-34.9 = obesity class I; BMI 35.0-39.9 = obesity class II; BMI ≥40.0 = obesity class III (National Heart, Lung, and Blood Institute (NHLBI), n.d.).
4.2.1.2 Changes in Exercise Self-Efficacy and Behaviour Outcomes

Throughout the course of the CR program, there was a general tendency for exercise SE scores to increase (Figure 2). A decrease in confidence was noticed between months 1 (i.e. week 4) and 2 (i.e. week 8) as noted on the MSES questionnaire (96.67% to 91.11%; respectively); however, SE scores increased monthly after this time point. Peak confidence was reached at discharge, at a SE rating of 97.78%. Compared to baseline, Mr. A demonstrated a 12.8% improvement in exercise SE after discharge (86.67% to 97.78%; respectively). Based on these improvements, a concomitant increase in PA behaviour was noticed; as measured by average daily step counts (Figure 3). Throughout the 16-week CR program, there was a general tendency for daily step counts to increase; except for month 2 (i.e. week 8) where there was a slight decrease in the number of steps completed. By the end of the intervention, Mr. A demonstrated an overall increase of 2,540 steps/day from baseline (8,097 steps/day to 10,637 steps/day; respectively); equating to a 31.4% improvement in improvement in PA behaviour.
Figure 2: Monthly exercise self-efficacy scores for Mr. A

Figure 3: Average daily step counts, on a monthly basis, for Mr. A
4.2.1.3 Changes in Physical Function Outcomes

The improvement in PA behaviour may subsequently explain the positive physical function outcomes demonstrated at discharge (Table 9). Prior to starting the CR program, Mr. A completed a Slow Ramp treadmill stress test at HDH (Appendix L). He exercised for 10:32 minutes:seconds, achieving a peak workload of 6.70 METs. This level of exertion equates to a sex- and age-adjusted peak aerobic capacity within the 10-15th percentile range, according to the ACSM guidelines (ACSM & Pescatello, 2014). This man’s HR_{resting} rose from 50 bpm to a maximal level of 100 bpm, representing a value of 68% of the maximal, age-predicted HR. Resting BP began at a hypertensive systolic value (i.e. 140/76 mmHg) and rose to a peak value of 170/78 mmHg. The GXT was stopped due to leg fatigue, with a RPE of 7 on the 0-10 Borg Scale.

At the time of the discharge exercise testing, Mr. A was able to exercise according to the Regular Ramp protocol (Appendix L) for 12:55 minutes:seconds, achieving a peak workload of 11.0 METs. This increase in aerobic capacity represents an improvement of 64.2% from baseline, representing a movement to the 85-90th percentile score (for his age and sex) (ACSM & Pescatello, 2014). Maximal, age-predicted HR rose to 107%, with resting and maximal values of 52 bpm and 157 bpm respectively. Resting BP represented a hypertensive value of 162/82 mmHg, which then rose to a maximal value of 176/90 mmHg. Within this GXT, exercise testing was stopped due to dyspnea after achieving the same RPE as baseline.

In terms of lower extremity function and power, clinically significant improvements were found on the 30CST outcome measure (Table 9). Compared to baseline, Mr. A was able to complete 5 additional chair-stand repetitions resulting in an improvement of 27.8%. This increase in the number of STS maneuvers represents a clinically relevant value above the minimal detectable change documented for this outcome measure (i.e. MDC_{95} = 2.6 repetitions) (Overend
Moreover, the improvement in lower extremity function may extrapolate to an increase in muscle power. This can be understood by looking at the change in reasoning for the termination of exercise testing between baseline and discharge. After participating in the CR program, Mr. A reached volitional exhaustion as a result of shortness of breath; whereas at baseline, they stopped the treadmill test due to leg fatigue. In terms of lower extremity power, performance on the SCT at discharge was 0.4 seconds faster than baseline; equating to a 9.1% improvement. This decrease in time is indicative of an increase in speed or muscle power; however, is not clinically significant as an overall reduction of 5.5 seconds is needed to discern a minimal detectable change from baseline (Kennedy et al., 2005).

Functional balance, as measured by the BBS, did not show a minimal detectable change from baseline (Table 9). A change of 3.3 points is required to reveal a genuine change from baseline (i.e. when the initial BBS score is 45-56 points), whereby a 1.0 point difference was noted at discharge (Donoghue & Stokes, 2009). Item #8 (‘Reaching forward with outstretched arm while standing’) was the only task that deteriorated from baseline to the end of CR. Mr. A received a score of 3 (‘can reach forward 12 cm’) on this item, as they were only able to outstretch their arm by 18 cm, compared to a value of 4 (‘can reach forward confidently 25 cm’) at baseline, where they could securely reach a distance of 38 cm.
Table 9: Change in physical function outcomes for Mr. A

<table>
<thead>
<tr>
<th></th>
<th>Baseline</th>
<th>Discharge</th>
<th>Change Score</th>
<th>Clinically Significant Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak aerobic capacity (METs)</td>
<td>6.70</td>
<td>11.00</td>
<td>+4.30</td>
<td>0.5 MET</td>
</tr>
<tr>
<td>30CST (# of repetitions)</td>
<td>18.0 ± 1.0</td>
<td>23.0 ± 6.2</td>
<td>+5.0</td>
<td>2.6 repetitions</td>
</tr>
<tr>
<td>SCT (secs)</td>
<td>4.5 ± 0.1</td>
<td>4.1 ± 0.5</td>
<td>-0.4</td>
<td>5.5 seconds</td>
</tr>
<tr>
<td>BBS</td>
<td>56.0</td>
<td>55.0</td>
<td>-1.0</td>
<td>3.3 points</td>
</tr>
</tbody>
</table>

30CST = 30-second chair stand test; BBS = Berg Balance Scale; METs = Metabolic equivalents; SCT = Stair climb test. **NOTE:** three trials of the 30CST and SCT were completed at baseline and discharge (mean ± SD).

4.2.1.4 Cardiovascular Disease Risk Factor Profile

Baseline and discharge values for the CVD risk factors are presented in Table 10; alongside their associated target levels. With respect to body composition, Mr. A fell within the optimal value for both BMI and WC according to the KDIGO and WHO guidelines respectively (KDIGO, 2013b; WHO, 2000). A change in WC was recorded (i.e. a reduction from 81.0 cm to 80.0 cm); however, the change of 1.0 cm falls within the intra-rater measurement error for this outcome (i.e. 1.56 cm) (Lohman et al., 1988). Resting BP increased by the end of CR, by a value specific to those with pre-diabetes (i.e. > 130/80 mmHg vs. > 140/90 mmHg for the general population).

Overall, indications of glucose metabolism were unaltered at the time of discharge as compared to baseline values. Improvements in two of the five serum lipid measures were observed at the time of discharge. Both TC and LDL-C values reached target levels, according to the KDIGO and NCEP Expert Panel guidelines respectively (Expert Panel on Detection, 2001; KDIGO, 2013b); while HDL-C, TC/HDL-C, and TG remained within optimal ranges. An improvement of 7.7% was demonstrated for the TC measurement (4.65 mmol/L at baseline to
4.29 mmol/L at discharge). Similarly, the reduction in the level of LDL-C equated to a 14.1% improvement (2.91 mmol/L at baseline to 2.50 mmol/L at discharge). Lastly, findings pointed to an improvement in kidney function at the time of completion of CR. The calculated eGFR improved to 28.0-mL/min/1.73 m² by discharge, not only demonstrating the effect of preventing the usual decline over time but translating into keeping Mr. A within Stage 4 CKD (i.e. 15-29 mL/min/1.73 m²).

Table 10: Clinical characteristics of Mr. A

<table>
<thead>
<tr>
<th>Anthropometrics and Cardiovascular Outcomes</th>
<th>Baseline</th>
<th>Discharge</th>
<th>Target Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Height (m)</td>
<td>171.9</td>
<td>171.9</td>
<td>-</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>62.2</td>
<td>61.9</td>
<td>-</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>21.1</td>
<td>21.0</td>
<td>20.0-25.0</td>
</tr>
<tr>
<td>WC (cm)</td>
<td>81.0</td>
<td>80.0</td>
<td>&lt;94.0</td>
</tr>
<tr>
<td>Resting HR (bpm)</td>
<td>47</td>
<td>49</td>
<td>-</td>
</tr>
<tr>
<td>Resting SBP (mmHg)</td>
<td>129</td>
<td>136</td>
<td>&lt;130</td>
</tr>
<tr>
<td>Resting DBP (mmHg)</td>
<td>69</td>
<td>73</td>
<td>&lt;80</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Glucose Profile</th>
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</tr>
</thead>
<tbody>
<tr>
<td>HbA1c (%)</td>
<td>5.8</td>
<td>5.8</td>
<td>~7</td>
</tr>
<tr>
<td>FBS (mmol/L)</td>
<td>5.6</td>
<td>5.6</td>
<td>4.0-6.0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Lipid Profile</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>TC (mmol/L)</td>
<td>4.65</td>
<td>4.29</td>
<td>&lt;4.50</td>
</tr>
<tr>
<td>HDL-C (mmol/L)</td>
<td>1.45</td>
<td>1.55</td>
<td>≥1.00</td>
</tr>
<tr>
<td>TC/HDL-C</td>
<td>3.21</td>
<td>2.77</td>
<td>&lt;4.00</td>
</tr>
<tr>
<td>LDL-C (mmol/L)</td>
<td>2.91</td>
<td>2.50</td>
<td>&lt;2.60</td>
</tr>
<tr>
<td>TG (mmol/L)</td>
<td>0.62</td>
<td>0.52</td>
<td>&lt;1.70</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Renal Outcomes</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>eGFR (mL/min/1.73 m²)</td>
<td>24.0</td>
<td>28.0</td>
<td>-</td>
</tr>
<tr>
<td>CKD stage</td>
<td>4</td>
<td>4</td>
<td>-</td>
</tr>
</tbody>
</table>

BMI = Body mass index; CKD = Chronic kidney disease; DBP = Diastolic blood pressure; eGFR = Estimated glomerular filtration rate; FBS = Fasting blood sugar; HbA1c = Glycated hemoglobin; HDL-C = High-density lipoprotein cholesterol; HR = Heart rate; LDL-C = Low-density lipoprotein cholesterol; SBP = Systolic blood pressure; TG = Triglycerides; TC = Total cholesterol.
4.2.1.5 Changes in Self-Management Behaviours

Among the SM behaviours, medication adherence was the highest self-reported item at both baseline and discharge (4.0) (Figure 4). This indicates that Mr. A took his medications as prescribed ‘all of the time’. Self-care was the second most performed category of behaviour by the end of CR. Compared to baseline, a 24.7% improvement was demonstrated in this dimension at the completion of the intervention (2.55 to 3.18; respectively). Of the remaining activities, partnership in care was the construct with the largest increase from baseline (1.43 at baseline to 2.71 at discharge). This represents an improvement of 89.5% (i.e. net change of 1.28 points), where Mr. A was now able to execute this activity almost ‘all of the time’. The least often performed behaviour was self-advocacy (1.10), which did not improve or decline at the completion of CR, followed by the communication construct of SM (i.e. 2.13 at discharge).

Figure 4: Baseline and discharge self-management behaviour measurements for Mr. A
4.2.2 Participant 2: Ms. B

4.2.2.1 Demographic Characteristics

Ms. B is a 71-year-old female with Stage 4 CKD (baseline eGFR = 18.0 mL/min/1.73 m$^2$). She was admitted to the HDH-CRC on December 3$^{rd}$, 2014 for her initial Screening Clinic visit and began on-site EXT sessions on a twice-weekly basis starting January 19$^{th}$, 2014 (Monday/Wednesday schedule). Table 11 outlines her demographic characteristics.

Prior to beginning the CR program, Ms. B demonstrated two key non-modifiable CVD risk factors (i.e. advancing age and white race), alongside one modifiable CVD risk factor (i.e. presenting with Class I obesity [31.3 kg/m$^2$]). In addition, she is a reformed smoker having smoked ½ a pack per day for 50 years.

Table 11: Demographic characteristics of Ms. B at baseline

<table>
<thead>
<tr>
<th>Demographics</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>71.0</td>
</tr>
<tr>
<td>Sex (M/F)</td>
<td>F</td>
</tr>
<tr>
<td>Race</td>
<td>Caucasian</td>
</tr>
<tr>
<td>Marital status</td>
<td>Widow</td>
</tr>
<tr>
<td>Occupational status</td>
<td>Retired</td>
</tr>
<tr>
<td>Medications</td>
<td>None</td>
</tr>
<tr>
<td>Cardiovascular Disease Risk Factors</td>
<td></td>
</tr>
<tr>
<td>Diabetic status</td>
<td>Non-diabetic</td>
</tr>
<tr>
<td>Hypertension? (Y/N)</td>
<td>N</td>
</tr>
<tr>
<td>Dyslipidemia? (Y/N)</td>
<td>N</td>
</tr>
<tr>
<td>Sedentary lifestyle? (Y/N)</td>
<td>N</td>
</tr>
<tr>
<td>Obese? (Y/N)</td>
<td>Y</td>
</tr>
<tr>
<td>Smoking status</td>
<td>Reformed smoker</td>
</tr>
</tbody>
</table>

M = Male; F = Female; Y = Yes; N = No. Note: obesity was determined based on the following classification: BMI 18.5-24.9 = normal weight; BMI 25.0-29.9 = overweight; BMI 30.0-34.9 = obesity class I; BMI 35.0-39.9 = obesity class II; BMI ≥40.0 = obesity class III (NHLBI, n.d.).
4.2.2.2 Changes in Exercise Self-Efficacy and Behaviour Outcomes

Throughout the course of the CR program, Ms. B did not exhibit any overall changes in exercise SE scores (Figure 5). An increase in exercise SE was observed between months 1 (i.e. week 4) and 3 (i.e. week 12) (78.89%; 81.11%; 86.67%, respectively); however, SE scores decreased below baseline by discharge (84.44% at baseline to 80.00% after the completion of CR). Despite the overall consistency in confidence levels, a positive improvement in PA behaviour was noticed – as measured by average daily step counts (Figure 6). Ms. B was able to reach the target step count of ≥10,000 steps/day, as set by the HDH-CRC, every month after baseline (13, 966; 10, 369; 11, 337; and 10, 399 steps/day, respectively). This increase of 2,118 steps/day from baseline (i.e. 8,281 steps/day to 10,399 steps/day) equated to a 25.6% improvement in PA behaviour.
4.2.2.3 Changes in Physical Function Outcomes

The improvement in PA behaviour may subsequently explain the positive physical functional outcomes demonstrated at discharge (Table 12). Prior to starting the CR program, Ms. B completed a Regular Ramp treadmill test at HDH (Appendix L). She exercised for 08:01 minutes:seconds, achieving a peak workload of 7.50 METs. This level of exertion equates to a sex- and age-adjusted peak aerobic capacity in the 40-45th percentile range (ACSM & Pescatello, 2014). During the pre-rehabilitation GXT, her $HR_{resting}$ rose from 109 bpm to a maximal level of 150 bpm; representing a value of 85% of the maximal, age-predicted HR. Resting BP rose from 100/65 mmHg to 140/90 mmHg at its maximal point, suggesting a greater than expected DBP
change (Bourlaug et al., 2006). The GXT was stopped due to Ms. B not being able to keep up with the protocol, at a RPE of 8 on the 0-10 Borg Scale. At the time of discharge exercise testing, Ms. B exercised according to the same protocol, now for 12:04 minutes:seconds, achieving a peak workload of 10.30 METs. This increase in aerobic capacity represents an improvement of 37.3% from baseline, representing a movement to the 90-95th percentile (for her age and sex) (ACSM & Pescatello, 2014). Maximal, age-predicted HR rose to 100%, with resting and maximal values of 67 bpm and 150 bpm respectively. Resting BP rose from 104/60 mmHg to a maximal value of 128/60 mmHg. Within this GXT, exercise testing was stopped due to leg fatigue after achieving an RPE of 10.

In terms of lower extremity function and power, clinically significant improvements were only seen within the 30CST outcome (Table 12). Compared to baseline, Ms. B was able to complete 4 additional chair-stand repetitions resulting in an improvement of 20.0%. This increase in the number of STS repetitions represents a clinically relevant value above the minimal detectable change documented for this outcome measure (i.e. MDC95 = 2.6 repetitions) (Overend et al., 2010). This increase, however, should be understood with caution as the participant only completed 2 trials of the 30CST (both at baseline and discharge). Within each measurement time point, Ms. B reported knee pain as a limitation to completing an extra trial. In terms of lower extremity power, performance on the SCT at discharge was 0.8 seconds faster than baseline; equating to a 16.7% improvement. This decrease in time is indicative of an increase in speed or muscle power; however, is not clinically significant as an overall reduction of 5.5 seconds is needed to discern a minimal detectable change from baseline (Kennedy et al., 2005).
Functional balance, as measured by the BBS, additionally showed an improvement from baseline (Table 12). Though not clinically significant (i.e. a change of 3.3 points is required to reveal a genuine change from baseline, when the initial BBS score is 45-56 points), a 2-point difference was noticed equating to a 3.7% change difference (Donoghue & Stokes, 2009). Item #8 (‘Reaching forward with outstretched arm while standing’) was the only task in which Ms. B improved from baseline to the end of the CR intervention. She received a score of 2 (‘can reach forward 5 cm’) while completing the reaching task at baseline, as they were only able to outstretch their arms by 9.5 cm, compared to 4 (‘can reach forward confidently 25 cm’) at discharge, where they could securely reach over the maximal target distance.

Table 12: Change in physical function outcomes for Ms. B

<table>
<thead>
<tr>
<th>Baseline</th>
<th>Discharge</th>
<th>Change Score</th>
<th>Clinically Significant Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak aerobic capacity (METs)</td>
<td>7.50</td>
<td>10.30</td>
<td>+2.80</td>
</tr>
<tr>
<td>30CST (# of repetitions)</td>
<td>20.0 ± 0.0*</td>
<td>24.0 ± 1.4*</td>
<td>+4.0</td>
</tr>
<tr>
<td>SCT (secs)</td>
<td>4.9 ± 0.5</td>
<td>4.1 ± 0.1</td>
<td>-0.8</td>
</tr>
<tr>
<td>BBS</td>
<td>54.0</td>
<td>56.0</td>
<td>+2.0</td>
</tr>
</tbody>
</table>

30CST = 30-second chair stand test; BBS = Berg Balance Scale; METs = Metabolic equivalents; SCT = Stair climb test. NOTE: three trials SCT were completed at baseline and discharge (mean ± SD). * Only two trials of the 30CST were completed at baseline and discharge (mean ± SD).
4.2.2.4 Cardiovascular Disease Risk Factor Profile

Baseline and discharge values for the CVD risk factors are presented Table 12, alongside their associated target levels. With respect to body composition, Ms. B fell outside the optimal value for both BMI and WC according to the KDIGO and WHO guidelines; respectively (KDIGO, 2013b; WHO, 2000). A reduction in the amount of tissue mass (muscle, fat, and bone) was noticed by the end of CR, with a BMI change from 31.3 kg/m$^2$ to 29.5 kg/m$^2$; however, she still fell within the ‘overweight’ BMI category. Resting BP fell after the completion of CR, in terms of both systolic and diastolic measurements (127/75 mmHg to 96/63 mmHg).

Overall, indications of glucose metabolism were unaltered at the time of CRC discharge as compared to baseline values. Improvements in four of the five serum lipid measures were observed at the time of discharge. The amount of HDL-C slightly decreased; while TC/HDL-C, LDL-C, and TG values marginally increased. TC was the one blood measurement that fell outside the target level at the end of CR. A 116.8% increase in the level of TC was noticed, due to the net increase of 2.57 mmol/L by discharge. Lastly, it is noticed that kidney function remained unchanged after the completion of CR with eGFR deteriorating slightly (i.e. by 1.0 mL/min/1.73 m$^2$); however, this participant’s disease continued to be categorized as Stage 4 CKD.
Table 13: Clinical characteristics of Ms. B

<table>
<thead>
<tr>
<th></th>
<th>Baseline</th>
<th>Discharge</th>
<th>Target Level</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Anthropometrics and Cardiovascular Outcomes</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Height (m)</td>
<td>164.1</td>
<td>164.1</td>
<td>-</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>84.4</td>
<td>79.6</td>
<td>-</td>
</tr>
<tr>
<td>BMI (kg/m$^2$)</td>
<td>31.3</td>
<td>29.5</td>
<td>20.0-25.0</td>
</tr>
<tr>
<td>WC (cm)</td>
<td>95.5</td>
<td>96.5</td>
<td>&lt;80.0</td>
</tr>
<tr>
<td>Resting HR (bpm)</td>
<td>65</td>
<td>67</td>
<td>-</td>
</tr>
<tr>
<td>Resting SBP (mmHg)</td>
<td>127</td>
<td>96</td>
<td>&lt;140</td>
</tr>
<tr>
<td>Resting DBP (mmHg)</td>
<td>75</td>
<td>63</td>
<td>&lt;90</td>
</tr>
<tr>
<td><strong>Glucose Profile</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HbA1c (%)</td>
<td>5.2</td>
<td>5.5</td>
<td>~7</td>
</tr>
<tr>
<td>FBS (mmol/L)</td>
<td>4.3</td>
<td>5.0</td>
<td>4.0-6.0</td>
</tr>
<tr>
<td><strong>Lipid Profile</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TC (mmol/L)</td>
<td>2.20</td>
<td>4.77</td>
<td>&lt;4.50</td>
</tr>
<tr>
<td>HDL-C (mmol/L)</td>
<td>2.30</td>
<td>1.88</td>
<td>≥1.30</td>
</tr>
<tr>
<td>TC/HDL-C</td>
<td>0.96</td>
<td>2.54</td>
<td>&lt;4.00</td>
</tr>
<tr>
<td>LDL-C (mmol/L)</td>
<td>2.50</td>
<td>2.53</td>
<td>&lt;2.60</td>
</tr>
<tr>
<td>TG (mmol/L)</td>
<td>0.48</td>
<td>0.79</td>
<td>&lt;1.70</td>
</tr>
<tr>
<td><strong>Renal Outcomes</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>eGFR (mL/min/1.73 m$^2$)</td>
<td>18.0</td>
<td>17.0</td>
<td>-</td>
</tr>
<tr>
<td>CKD stage</td>
<td>4</td>
<td>4</td>
<td>-</td>
</tr>
</tbody>
</table>

BMI = Body mass index; CKD = Chronic kidney disease; DBP = Diastolic blood pressure; eGFR = Estimated glomerular filtration rate; FBS = Fasting blood sugar; HbA1c = Glycated hemoglobin; HDL-C = High-density lipoprotein cholesterol; HR = Heart rate; LDL-C = Low-density lipoprotein cholesterol; SBP = Systolic blood pressure; TG = Triglycerides; TC = Total cholesterol.

4.2.2.5 Changes in Self-Management Behaviours

Among the SM behaviours, medication adherence was the highest self-reported item at both baseline and discharge (4.0) (Figure 7). By contrast, the self-advocacy construct was the least often performed activity, which remained consistent after each measurement. With a score of 1.00, this participant ‘never’ felt willing to act positively in their own self-interest, to make decisions for themselves, to negotiate with health care professionals, or to exercise control over
their own care and treatment. Self-care was the second most executed dimension of behaviour at discharge. Compared to baseline, a 3.0% improvement was demonstrated by the end of CR (3.00 to 3.09; respectively). Of the remaining activities, both the communication and partnership in care activities demonstrated a decrease in performance from baseline to the completion of CR. The former construct showed the largest reduction at discharge, with a decline in execution of 24.7% (i.e. 1.50 to 1.13; respectively) compared to a 17.8% regression in the latter behaviour.

Figure 7: Baseline and discharge self-management behaviour measurements for Ms. B
4.2.3 Participant 3: Mr. C

4.2.3.1 Demographic Characteristics

Mr. C is a 72-year-old male with Stage 3b CKD (baseline eGFR = 41.0 mL/min/1.73 m²). He was admitted to the HDH-CRC on December 12th, 2014 for his initial Screening Clinic visit and began on-site EXT sessions on a twice-weekly basis starting January 28th, 2014 (Monday/Wednesday schedule). Table 14 outlines his demographic characteristics.

Prior to beginning the CR program, Mr. C demonstrated three non-modifiable CVD risk factors (i.e. male sex, white race, advancing age), alongside five modifiable CVD risk factors. He presented with type 2 diabetes, HTN (managed using beta-blockade), dyslipidemia (characterized as high TC and TG levels, and low HDL-C levels), a sedentary lifestyle, and obesity. He was also a reformed smoker, who smoked 2.5 packs per day for 24 years.

Table 14: Demographic characteristics of Mr. C at baseline

<table>
<thead>
<tr>
<th>Demographics</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>72</td>
</tr>
<tr>
<td>Sex (M/F)</td>
<td>M</td>
</tr>
<tr>
<td>Race</td>
<td>Caucasian</td>
</tr>
<tr>
<td>Marital status</td>
<td>Married</td>
</tr>
<tr>
<td>Occupational status</td>
<td>Retired</td>
</tr>
<tr>
<td>Medications</td>
<td>Antiplatelet, anticoagulant, ACE inhibitor, statin, beta-blocker, diuretic, insulin</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Cardiovascular Disease Risk Factors</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Diabetic status</td>
<td>Diabetic</td>
</tr>
<tr>
<td>Hypertension? (Y/N)</td>
<td>Y</td>
</tr>
<tr>
<td>Dyslipidemia? (Y/N)</td>
<td>Y</td>
</tr>
<tr>
<td>Sedentary lifestyle? (Y/N)</td>
<td>Y</td>
</tr>
<tr>
<td>Obese? (Y/N)</td>
<td>Y</td>
</tr>
<tr>
<td>Smoking status</td>
<td>Reformed smoker</td>
</tr>
</tbody>
</table>

M= Male; F = Female; Y = Yes; N = No. Note: obesity was determined based on the following classification: BMI 18.5-24.9 = normal weight; BMI 25.0-29.9 = overweight; BMI 30.0-34.9 = obesity class I; BMI 35.0-39.9 = obesity class II; BMI ≥40.0 = obesity class III (NHLBI, n.d.).
4.2.3.2 Changes in Exercise Self-Efficacy and Behaviour Outcomes

Throughout the course of the CR program, there was a general tendency for exercise SE scores to increase (Figure 8). An increase in exercise SE was observed from baseline to month 2 (i.e. week 8) on the MSES questionnaire (86.67 %; 88.89%; 96.56%, respectively); however, SE scores decreased by month 3 (i.e. week 12) (i.e. 95.56% to 92.78%). Peak confidence was reached at discharge, at a SE rating of 96.67%. Compared to baseline, Mr. C demonstrated an 11.5% improvement in confidence after completion of the CR intervention (i.e. 86.67% to 96.67%). Based on these improvements, a concomitant increase in PA behaviour was noticed; as measured by average daily step counts (Figure 9). Due to a significant life event (i.e. house fire), measurements were not available for month 1 (i.e. week 4); however, data suggests that Mr. C would have achieved a step count between baseline and month 2 (i.e. week 8) – given the trajectory of the following months. His largest improvement in step count was noticed from baseline to discharge (i.e. an increase of 5,862 steps/day); though the final measurement did not meet the target step count set by HDH-CRC. Despite not reaching ≥10,000 steps/day at any time point throughout the intervention, Mr. C was able to improve his daily step count from baseline by 260.5%.
Figure 8: Monthly exercise self-efficacy scores for Mr. C

Figure 9: Average daily step counts, on a monthly basis, for Mr. C
4.2.3.3 Changes in Physical Function Outcomes

The improvement in PA behaviour for Mr. C does not seem to translate into many positive physical functional outcomes demonstrated at discharge (Table 15). Prior to starting the CR program, Mr. C completed a Slow Ramp treadmill test at HDH (Appendix L). He exercised for 09:52 minutes:seconds, achieving a peak workload of 6.30 METs. This level of exertion equates to a sex- and age-adjusted peak aerobic capacity within the 5-10\textsuperscript{th} percentile range (ACSM & Pescatello, 2014). His $HR_{resting}$ rose from 75 bpm to a maximal level of 146 bpm, with the peak representing a value of 83\% of the maximal, age-predicted HR. An elevated resting SBP of 152/60 mmHg, likely a reflection of pre-testing anxiety, reached a peak value of 232/65 mmHg – representing exertion-induced systolic HTN. In the context of a minimal change in DBP, the diastolic finding may be a reflection of an excellent performance effort. The GXT was stopped due to perceived shortness of breath (i.e. dyspnea), with a RPE of 8 on the 0-10 Borg Scale. At the time of discharge exercise testing, Mr. C exercised according to the same protocol; now for 10:28 minutes:seconds, achieving a peak workload of 6.70 METs. This increase in aerobic capacity represents an improvement of 6.3\% from baseline, representing a movement to the 10-15\textsuperscript{th} percentile (for his age and sex) (ACSM & Pescatello, 2014). Maximal, age-predicted HR declined to 75\%, with resting and maximal values of 58 bpm and 111 bpm respectively. Resting BP rose from a value of 140/60 mmHg to a maximal value of 170/60 mmHg. Within this GXT, exercise testing was stopped due to fatigue and dyspnea after achieving a RPE of 9.

In terms of lower extremity function and power, declines in each outcome were demonstrated among the 30CST and SCT measurements; though neither was clinically significant (Table 15). Compared to baseline, Mr. C was able to complete approximately 2 fewer chair-stand repetitions resulting in a reduction of 10.2\%. He achieved his lowest repetition within
trial 2 of discharge (i.e. 11 chair stands). In terms of lower extremity power, performance on the SCT at discharge was 0.3 seconds faster than baseline; equating to a 4.5% improvement. This decrease in time is indicative of an increase in speed or muscle power; however, is not clinically significant as an overall reduction of 5.5 seconds is needed to discern a minimal detectable change from baseline (Kennedy et al., 2005).

Functional balance, as measured by the BBS, did not show a clinically relevant improvement from baseline (Table 15). A change of 3.3 points is required to reveal a genuine change from baseline (i.e. when the initial BBS score is 45-56 points), where only a 3-point difference was noted (Donoghue & Stokes, 2009). Items #8 (‘Reaching forward with outstretched arm while standing’), #12 (‘Place alternate foot on step or stool while standing unsupported’), #13 (‘Standing unsupported one foot in front’) and #14 (‘Standing on one leg’) were the tasks at baseline in which Mr. C scored a value of 3. By the end of the CR intervention, he was able to improve his ratings on tasks 12-14 (i.e. improving to a score of 4); however, remained at the same score on task 8. Within item #12, Mr. C received a rating of 3 (‘able to stand independently and complete 8 steps in >20 seconds’) at baseline, due to his inability to complete the task within the time frame. In terms of item #13, he initially scored a 3 (‘able to place foot ahead independently and hold 30 seconds) as Mr. C was unstable and had to readjust his positioning to complete the task. Lastly, he received a rating of 3 (‘able to stand independently using hands’) on item #14 as Mr. C was not able to complete this task within the time frame needed to score a 4 (i.e. ‘able to lift leg independently and hold for >10 seconds); he unfortunately only maintained his position for 9 seconds.
Table 15: Change in physical function outcomes for Mr. C

<table>
<thead>
<tr>
<th></th>
<th>Baseline</th>
<th>Discharge</th>
<th>Change Score</th>
<th>Clinically Significant Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak aerobic capacity (METs)</td>
<td>6.30</td>
<td>6.70</td>
<td>+0.40</td>
<td>0.5 MET</td>
</tr>
<tr>
<td>30CST (# of repetitions)</td>
<td>16.3 ± 1.5</td>
<td>14.7 ± 3.5</td>
<td>-1.6</td>
<td>2.6 repetitions</td>
</tr>
<tr>
<td>SCT (secs)</td>
<td>5.4 ± 0.1</td>
<td>5.1 ± 0.1</td>
<td>-0.3</td>
<td>5.5 seconds</td>
</tr>
<tr>
<td>BBS</td>
<td>52.0</td>
<td>55.0</td>
<td>+3.0</td>
<td>3.3 points</td>
</tr>
</tbody>
</table>

30CST = 30-second chair stand test; BBS = Berg Balance Scale; METs = Metabolic equivalents; SCT = Stair climb test. **NOTE:** three trials of the 30CST and SCT were completed at baseline and discharge (mean ± SD).

4.2.3.4 Cardiovascular Disease Risk Factor Profile

Baseline and discharge values for the CVD risk factors are presented in **Table 16**, alongside their associated target levels. With respect to body composition, Mr. C fell outside the optimal value for both BMI and WC according to the KDIGO and WHO guidelines; respectively (KDIGO, 2013b; WHO, 2000). An increase in the volume of tissue mass (muscle, fat, and bone) was noticed by the end of CR, with a BMI change from 30.8 kg/m² to 31.6 kg/m²; alongside, a net increase in girth of 2.5 cm. Systolic BP rose to hypertensive levels by the end of CR, specific to those with DM (i.e. >130/80 mmHg for diabetics vs. >140/90 mmHg for non-diabetics).

In terms of the blood laboratory results, values for the glucose profile improved both clinically and empirically after the completion of CR. The average plasma glucose concentration over 3 months reached target levels after discharge, representing a clinical improvement. FBS decreased upon completion of CR (i.e. 11.3 mmol/L at baseline to 10.5 mmol/L at discharge); though it did not fall within the target range at either measurement point. When looking at serum lipid values, improvements in two of the five serum lipid measures were observed at the time of discharge. Both TC/HDL-C and TG values reached target levels, according to the NCEP Expert
Panel guidelines (Expert Panel on Detection, 2001); while TC, HDL-C, and LDL-C remained within optimal values. An empirical improvement of 33.7% was demonstrated for the TC measurement (i.e. 4.06 mmol/L to 2.69 mmol/L; respectively), equating to a net change of 1.37 mmol/L. Lastly, a clinically relevant deterioration in kidney function was demonstrated after the completion of CR. Estimated GFR decreased from 41.0 mL/min/1.73 m² at baseline to 29.0 mL/min/1.73 m² by discharge, moving Mr. C into Stage 4 CKD.

Table 16: Clinical characteristics of Mr. C

<table>
<thead>
<tr>
<th>Anthropometrics and Cardiovascular Outcomes</th>
<th>Baseline</th>
<th>Discharge</th>
<th>Target Level</th>
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<tr>
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<td>176.2</td>
<td>-</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>95.5</td>
<td>98.1</td>
<td>-</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>30.8</td>
<td>31.6</td>
<td>20.0-25.0</td>
</tr>
<tr>
<td>WC (cm)</td>
<td>113.5</td>
<td>116.0</td>
<td>&lt;94.0</td>
</tr>
<tr>
<td>Resting HR (bpm)</td>
<td>78</td>
<td>66</td>
<td>-</td>
</tr>
<tr>
<td>Resting SBP (mmHg)</td>
<td>106</td>
<td>137</td>
<td>&lt;130</td>
</tr>
<tr>
<td>Resting DBP (mmHg)</td>
<td>79</td>
<td>64</td>
<td>&lt;80</td>
</tr>
<tr>
<td><strong>Glucose Profile</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HbA1c (%)</td>
<td>8.4</td>
<td>6.8</td>
<td>~7</td>
</tr>
<tr>
<td>FBS (mmol/L)</td>
<td>11.3</td>
<td>10.5</td>
<td>4.0-6.0</td>
</tr>
<tr>
<td><strong>Lipid Profile</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TC (mmol/L)</td>
<td>4.06</td>
<td>2.69</td>
<td>&lt;4.50</td>
</tr>
<tr>
<td>HDL-C (mmol/L)</td>
<td>0.81</td>
<td>0.79</td>
<td>≥1.00</td>
</tr>
<tr>
<td>TC/HDL-C</td>
<td>5.01</td>
<td>3.41</td>
<td>&lt;4.00</td>
</tr>
<tr>
<td>LDL-C (mmol/L)</td>
<td>1.28</td>
<td>1.12</td>
<td>&lt;2.60</td>
</tr>
<tr>
<td>TG (mmol/L)</td>
<td>4.29</td>
<td>1.55</td>
<td>&lt;1.70</td>
</tr>
<tr>
<td><strong>Renal Outcomes</strong></td>
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<td></td>
</tr>
<tr>
<td>eGFR (mL/min/1.73 m²)</td>
<td>41.0</td>
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</tr>
<tr>
<td>CKD stage</td>
<td>3b</td>
<td>4</td>
<td>-</td>
</tr>
</tbody>
</table>

BMI = Body mass index; CKD = Chronic kidney disease; DBP = Diastolic blood pressure; eGFR = Estimated glomerular filtration rate; FBS = Fasting blood sugar; HbA1c = Glycated hemoglobin; HDL-C = High-density lipoprotein cholesterol; HR = Heart rate; LDL-C = Low-density lipoprotein cholesterol; SBP = Systolic blood pressure; TG = Triglycerides; TC = Total cholesterol.
4.2.3.5 Changes in Self-Management Behaviours

Among the SM behaviours, medication adherence was the highest self-reported item at both baseline and discharge (4.0) (Figure 10). This indicates that Mr. C took his medications as prescribed ‘all of the time’. Self-care was the second most performed category of behaviour at discharge. Compared to baseline, an 8.6% improvement was demonstrated by the end of CR (i.e. 3.27 to 3.55; respectively). Of the remaining activities, communication was the construct with the largest increase in score from baseline (1.38 at baseline to 2.13 at the completion of CR). This represents an improvement of 54.4% (i.e. net change of 0.75 points), where Mr. C was now able to execute this activity ‘a few times’ over the course of the last 6 months compared to almost ‘never’. The least often performed behaviour was the self-advocacy at baseline (1.20), which declined after the completion of CR (1.00). This represents a reduction in execution of 16.7%
Chapter 5
Discussion

5.1 Primary Findings

The goals of this exploratory study were to gain preliminary information regarding: (a) the feasibility of recruiting and enrolling persons with CKD into CR (i.e. Phase I) and (b) the ability for CR to effectively impact on exercise SE among a cohort of individuals with CKD (i.e. Phase II). Previous studies have evaluated the barriers and facilitators to CR enrollment, as well as the changes in exercise SE, within CVD populations; however, none have evaluated either factor among those with CKD. To our knowledge, this is the first investigation to provide: (a) a quantification of recruitment and enrollment rates/ratios within a renal population offered participation in a CR program and (b) a description of the monthly changes in exercise SE scores among a cohort of patients with CKD. Upon completion of this study, our data illustrates similar findings to previous investigations evaluating the barriers and facilitators to CR enrollment, in addition to suggesting that CR may be an effective SM program for improving exercise SE in those with CKD.

5.1.1 Phase I: Recruitment

5.1.1.1 Recruitment and Enrollment Ratios, and the Factors Influencing the Utilization of Cardiac Rehabilitation

Within this pilot study, our 14-week accrual period rendered a substantially low recruitment and enrollment ratio. Among a cohort of 152 eligible participants, 7 individuals were accrued to Phase II of the study; however, only 3 were retained for enrollment after contact with
staff at the HDH-CRC. These findings represent a recruitment and enrollment ratio of 4.6% and 2.0%, respectively, which further translates into a recruitment rate of 0.5 participants/week. This data suggests that: (1) the accrual period may have been inadequate to acquire a critical mass of individuals; (2) the chosen recruitment strategy may have been ineffective in targeting our clinical population; and/or (3) there are specific patient-level barriers to CR enrollment.

First, when considering the accrual period, *a priori* calculations rendered a 14-week time frame as an appropriate period to screen all of the 700 renal patients managed by staff at the KGH Nephrology Program. Given that approximately 60 individuals are scheduled each week at the clinic, roughly 12 weeks would be needed to screen each chart; alongside a 2 week buffer period to account for any missing appointments and/or recruiter challenges. Despite this rationale, the research associate was unable to acquire a critical mass of subjects based on this chosen time frame. This difficulty in accruing patients with CKD to a research investigation is consistent with results from previous rehabilitation studies, including CR, whereby recruitment to health services is challenging among clinical populations. Acquiring a critical mass of individuals is a considerable challenge in any field, but has proven to be especially difficult within rehabilitation research (Chang, Hendricks, Slawsky, & Locastro, 2004; Ferland & Fortin, 1999; Walson, 1999). Recent estimates indicate that 85% of rehabilitation trials do not conclude on schedule – with 60-80% not meeting their temporal goals due to low participant accrual (Nitkin, 2003). More alarming is that almost 30% of rehabilitation studies do not even recruit a single study participant, rendering their investigations inconclusive (Blanton *et al.*, 2006; Nitkin, 2003).
Second, recruitment strategies in rehabilitation research often require a multi-faceted approach. When looking specifically at the CR literature, slightly better accrual statistics are noticed among studies using this rehabilitative service; particularly, due to the inherent referral strategies embedded in its structure. Within this health service, automatic referrals and physician endorsements are used as the principal means to refer and enroll patients in CR. Typically, electronic health records are used to prompt cardiologists to order a CR referral for all eligible cardiac patients; leading to a more effective strategy of accruing patients to CR investigations compared to standard research tactics alone (e.g. use of study personnel alone, advertisement in newspapers). The consistency in the use of either method, however, proves to be variable in practice; leading to a considerable challenge for research studies. In a systematic review conducted by Cortés and colleagues (2006), referral rates to CR varied widely across 9 observational studies – from as low as 10-30% (Barber et al., 2001; Bittner et al., 1999; Blackburn et al., 2000; Grace et al., 2002; King et al., 1999; Roblin et al., 2004; Scott et al., 2003) to as high as more than 60% (Grace et al., 2004; Spencer et al., 2001). The diverse rates of recruitment were primarily due to poor endorsements from patients’ physicians; which subsequently led to low enrollment rates of eligible patients. Grace and colleagues (2002) found that recruitment through a clinician’s referral can account for approximately 60% of the variability in participation levels among those attending CR (Grace et al., 2002).

Further evidence from the literature has shown that a subsequent recommendation from a clinician further increases accrual and enrollment rates to CR as compared to automatic referral alone (Ades, Waldmann, McCann, & Weaver, 1992b). Specifically, Ades and colleagues (1992b) found that, of all the predictors relating to CR enrollment (demographic, medical, psychosocial, practitioner referral), the most powerful factor leading to participation was the strength of the
primary physician’s recommendation \( (p < 0.0001) \) (Ades et al., 1992b). The lack of this referral strategy may have been the reason for the low recruitment and enrollment ratios noticed within our study. Upon screening of the eligible renal patients, a research associate was the principal personnel approaching individuals and offering them enrollment in the investigation. As the research associate was not one of the CKD patients’ regular healthcare practitioners, individuals may have perceived the offer of CR services as not necessary and/or important for the management of their condition. These finding, however, should be taken with caution, as the quantitative nature of our study did not allow for the probing of subjects’ reasons for non-participation. Other influences may have also contributed to the patient’s decision to use or decline the offer to this health service.

Third, there are other factors likely to have impacted CR participation rates among individuals with CKD. Through the lens of Andersen’s *Behavioral Model of Health Services Use*, utilization of CR can be understood by analyzing specific predisposing, enabling, and needs characteristics (see Table 4 in the Literature Review section for a list of factors under each of these characteristics) (Andersen & Newman, 1973; Grace et al., 2008). As reported in the literature, predisposing characteristics – such as age and sex – have frequently been revealed to affect enrollment rates to this rehabilitative service. Specifically, women (Ades et al., 1992a; Cottin et al., 2004; CDC, 2003; Evenson, Rosamond, & Luepker, 1998; Witt et al., 2004) and persons over the age of 65 (Cooper et al., 1999; Cottin et al., 2004; CDC, 2003; Evenson, Rosamond, & Luepker, 1998; Gallagher, McKinley, & Dracup, 2003; King, Humen, Smith, Phan, & Teo, 2001; Witt et al., 2004) have been shown to attend CR at lower rates than men and individuals younger than 65. In a study conducted by Grace and colleagues (2009), only 25.1% (n=133) of women with heart disease participated in a CR program as compared to 75.9%
of men ($p = 0.028$) (Grace et al., 2009a). Barriers to participation by sex were also identified, with the following factors affecting women to a greater extent than men: transportation ($p = 0.025$), family responsibilities ($p = 0.039$), lack of CR awareness ($p = 0.036$), experiencing exercise as tiring or painful ($p = 0.002$), and co-morbidities ($p = 0.009$) (Grace et al., 2009a).

Within our study, collected data revealed similar findings to those demonstrated in Grace’s (2008) investigation. Of the renal cohort approached and interested in enrolling in CR, only 31.0% (n=9) were women as compared to 69.0% (n=20) being male. Moreover, of those participants enrolled in the CR program, the majority of individuals were male (66.7%; n=2). The reasons women are missing from CR programs have been identified as multi-factorial and include health system, provider, and patient-level factors (Scott, Ben-Or, K., & Allen, 2002). For instance, as women often have lower socioeconomic status and are older at the time of a cardiac event (Limacher, 1998; Rosenfeld, 2000; Wenger, 2002), they may be less likely than men to have access to a car, leading to greater transportation barriers (Heid & Schmelzer, 2004; Marcuccio, Loving, Bennett, & Hayes, 2003; Radley, Grove, Wright, & Hurston, 1998; Halm, Penque, Doll, & Beahrs, 1999; Moore & Kramer, 1996). Moreover, women are more often the family caregivers than men, leaving less time for SM of their own conditions. For example, women may have a spouse or close family member with health problems for whom they provide care and often assume primary responsibility for household chores (Heid & Schmelzer, 2004). In order to understand the reasons for female non-participation in our renal cohort, further research will need to be conducted to investigate the specific barriers hindering their attendance to CR; however, it is hypothesized that similar barriers to enrollment may be evident within our population.
In terms of age differences, those over the age of 65 have been demonstrated to participate less in CR than younger cohorts. For instance, in a population-based study, persons with MI who were 70 years of age or older were 77% less likely to attend CR than those younger than 60 (Witt et al., 2004). When looking at our results, age may or may not have been a factor relating to non-participation among those eligible for participation. Of the 29 individuals interested in our investigation, upwards of 75% (n=22) were above 64 years of age; in addition to all of the participants enrolled to Phase II of the study being over the age of 70 (mean = 72.3 years old). This indicates that age may not have been a barrier to CR enrollment in this cohort. However, of those not interested in the study, over 75% were above the age of 64. Previous research has suggested that older patients are significantly less likely to attend CR as they are typically unaware of the service ($p = 0.01$), have other heart problems preventing them from participating ($p < 0.01$), they find exercise tiring or painful ($p = 0.01$), or they perceive CR as unnecessary to improve their current health status ($p < 0.01$) (Grace et al., 2009b). Moreover, older patients may come to expect to develop and cope with chronic conditions, whereas younger patients who develop heart disease prematurely may be more inclined to actively address their excess risk (Grace et al., 2009b). Further research is needed in order to understand the association between age and CR participation among CKD populations.

Alongside predisposing characteristics, such as age and sex, persons with CKD are also affected by enabling factors that impact their likelihood of attending CR. Enabling factors are those that serve as facilitators to health service utilization or, conversely, their absence as barriers to health service utilization. In the area of CR services, these characteristics include (but are not limited to): perceived social support, marital status, and distance/time to the facility; with previous findings demonstrating that patients specifically take geographic proximity to services
into consideration when making enrollment decisions (De Vos et al., 2012). In a study conducted by De Vos and colleagues (2012), patients who accepted enrollment in a CR program travelled shorter distances (mean = 13.8 km, median = 11.5 km) than those who declined the offer to the service (mean = 19.4 km, median = 15 km) (De Vos et al., 2012). Moreover, previous data among renal cohorts suggests that the majority of patients with Stage 3 CKD enrolled in CR travel approximately 0-30 minutes to their health facility (80.6%), with no individuals travelling in excess of 60 minutes (Pyka et al., 2014). This finding suggests that proximity to rehabilitative services plays a large factor in the utilization of CR among this population. In our study, findings support the hypothesis that those interested in attending the CR program at HDH live closer to the facility (20.5 ± 31.9 km) compared to those who declined the offer to the investigation (70.2 ± 38.1 km) (p <0.001). This equates to an estimated travel time of 20.3 ± 23.7 minutes and 53.6 ± 26.1 minutes, respectively (p <0.001); which parallels findings from Pyka and colleagues’ (2014) work. Such results from our pilot data demonstrate that renal patients in rural settings (such as in the South Eastern Ontario Local Health Integration Network) may lack the availability of, and access to, CR programs. Historically, the decision to build CR services have not been made on the basis of a thorough analysis of regional need, but generally emerge through local CR champions such as physicians (Grace et al., 2008). This has resulted in CR services being poorly distributed both globally and within Ontario (CCN, 2002). Using this information, it may be suggested that alternate means of transportation and/or promoting home-based CR services for patients with geographic barriers should be more widely advocated to ensure universal access to this rehabilitative service. Future research into perceived barriers and facilitators of CR participation among persons with CKD would help guide refinement of this paradigm to best serve the needs of this at risk population.
5.1.2 Phase II: Case Series

5.1.2.1 Changes in Self-Efficacy Levels and its Association to Physical Activity Behaviour

Using a case series approach, three persons with CKD experienced a +12.8%, -5.3%, and +11.5% change in overall exercise SE following participation in a 16-week CR program. To our knowledge, this is the first study to explore the feasibility of using the Multidimensional Self-Efficacy for Exercise Scale among patients with CKD enrolled in a CR program; alongside the only investigation to evaluate exercise SE within this population. When looking at previous investigations using this scale (Fraser & Rodgers, 2010; Rodgers et al., 2013), in addition to other studies using supplemental measures of exercise SE, it can be understood that our CKD cohort demonstrated greater improvements in exercise SE compared to those with heart disease participating in this rehabilitative service.

In one study conducted by Rodgers and colleagues (2013), investigators evaluated the change in MSES scores among heart disease patients enrolled in CR; alongside any associations between exercise SE and subsequent levels of PA (Rodgers et al., 2013). Findings demonstrated a 1.88% increase in overall exercise SE after completing a 6-8 week CR program (i.e. 74.43% at baseline vs. 75.83% at discharge); in addition to positive correlations between each of the SE constructs (i.e. task, coping, scheduling) and exercising one month post-CR (R = 0.31; 0.34; 0.47, respectively; p <0.05; 0.01; 0.001, respectively) (Rodgers et al., 2013). The change in scores on the MSES, however, are lower than other scales evaluating exercise SE among cardiac patients participating in CR. Bray and colleagues (2005) quantified exercise SE using a scale consisting of eight items reflecting participants’ confidence in their capabilities to “walk briskly (or exercise continuously)” for progressively longer time increments – ranging from 5-40 minutes (Bray & Cowan, 2005). This measure conformed closely to Bandura’s (1997) recommendations for
assessing SE beliefs (i.e. domain specific, hierarchical, and incorporation of both strength and magnitude dimensions) (Bandura, 1997), and was similar to those previously used in the PA and older adults literature (McAuley, Blissmer, Katula, & Duncan, 2000). Within this study, findings demonstrated a change in exercise SE scores of almost 5% (i.e. 83.57% at week 6 vs. 87.56% at week 10) among 25 CR outpatients at a large urban hospital in the United Kingston (Bray & Cowan, 2005). These values, however, were collected during the course of a 12-week CR program, compared to pre- and post-measurements utilized by Rodgers and colleagues (2013), which may explain the difference in change scores between these studies. It has been demonstrated that while engaging in CR, individuals receive the greatest improvements in exercise SE when there are active sources of social support (i.e. healthcare practitioner reassurance) and physical support (i.e. modeling via other subjects) encouraging individuals to participate in the program. Once left to adhere to the recommendations on their own, confidence tends to decrease as the ‘verbal persuasion’ and ‘vicarious experience’ sources of SE are no longer present. Despite the differences in findings from these investigations, however, persons with CKD in our study demonstrated exercise SE improvements greater than either of the mentioned studies.

Both males in our exploratory trial (i.e. Mr. A and Mr. C) exhibited improvements in their exercise SE scores of over 10% as compared to baseline (12.8% for Mr. A, and 11.5% for Mr. C). In addition, they also demonstrated a general trend in increasing confidence throughout the 16-week program; where monthly changes in MSES values ranged from 2.4-11.5% for Mr. A and 2.6-7.5% for Mr. C. These findings may imply that individuals with CKD are demonstrably an ideal cohort to receive exercise SE benefits from CR. Previous findings within CVD populations have reasoned that individuals who participate in this rehabilitative service gain valuable skills to
increase their confidence, allowing them to cope with any exercise obstacles and persevere in the face of exercise barriers. In addition, CR provides individuals with the resources they need to meet the situational demands associated with managing their health. (e.g. stress management, dietary counseling). Such strategies are especially important to acquire among those with CKD, as this population dedicates a large amount of their daily schedules to mediating and coping with numerous SM activities relating to their condition. Given the findings in our study, the SE strategies gained through participating in CR may have provided renal participants with the confidence they needed to perform the recommended exercises; in addition to offering them specific resources to help make healthcare decisions and perform self-directed activities related to disease and treatment implementation (Naik, Dyer, Kunik, & McCullough, 2009). The attainment of such skills may further be used to support and explain the improvements in PA behaviour demonstrated within our population; whereby achieving ‘performance mastery’ of the on-site exercises may have contributed to an increase in daily step counts.

Inherent in the structure of CR is the participation in aerobic and resistance EXT sessions. Individuals perform a variety of endurance and strength training activities, on a weekly basis, which progressively increase in difficulty as the participant accomplishes the task. This advancement in training intensity provides the individual with a frequent reminder that they are capable of executing difficult tasks, which they previously may have not believed they could attain. Such ‘performance mastery’ is a source of SE which CR participants gain through engagement in structured PA, which has been shown to generate subsequent improvements in PA behaviours; including adherence to recommended activities (Jeng & Brauwn, 1997; Vidmar & Rubinson, 1994), improvements in the total number of exercise minutes (Moore, Dolansky, Ruland, Pashkow, & Blackburn, 2003), and changes in aerobic capacity (i.e. estimated VO2peak,
reported as METs) (Brown, Laschinger, Hains, & Parry, 1991; Rejeski et al., 2003). Behaviour change can be described as a competency of the efficacy process in which individuals monitor their responses to taxing situations, observe similar individuals facing similar demands, appraise their coping resources, create optimistic self-beliefs, plan a course of action, perform the associated activities, and evaluate their outcomes (Conner & Norman, 2005). The development of such skills for adhering to rehabilitative exercise protocols is a central part of CR participants’ recovery, and may be effective in increasing PA behaviour among CKD populations as well.

In our study, the participants with renal disease were asked to attain specific PA standards as part of their exercise protocol – primarily the achievement of walking at least 10,000 steps per day. Both Mr. A and Ms. B achieved this walking standard by discharge (10,637 steps/day and 10,399 steps/day; respectively), with Mr. C just shy of the target (8,112 steps/day). Of interest, however, is the fact that Ms. B demonstrated a decrease in her exercise SE scores upon discharge from the CR program (i.e. 84.44% vs. 80.00%) compared to Mr. A (i.e. 86.67% vs. 97.78%).

Literature pertaining to the relationship between exercise SE and behaviour change indicates that those who report exercising more frequently (or achieving certain exercise/PA goals) also report higher confidence levels on related outcome measures. One reason as to why this relationship may not always persist relates to the specificity of the behaviour that SE outcomes measure. Bandura (1997) suggested that SE scales should always refer to the particular behaviour that is being measured, as the attainment of basic skills may not always translate into confidence surrounding the performance of that behaviour (Bandura, 1997). That is, the mere ability to perform a specific behaviour does not mean one has the confidence to perform it under all circumstances. For example performing a positive health behaviour, such as eating a healthy diet, might comprise of numerous skill subsets such as shopping for nutritious food, preparing and
storing the food at home, packing healthy lunches, and choosing dietary choices at a restaurant. Each component might be underpinned by different knowledge and skills, which may not be reflected on or measured by a ‘broad’ diet SE scale. Based on this information, it is understood that SE is a multi-dimensional construct and different skills/beliefs may be required to produce the desired outcome (Rodgers et al., 2008). In terms of our study, the MSES was specific to the exercises performed within the context of CR; whereas the behaviour we measured dealt with general PA levels (i.e. walking capacity). If a more specific scale pertaining to walking capacity was administered or a different measure of behaviour was chosen (i.e. exercise adherence), the relationship between exercise SE and behaviour may have been better understood for Ms. B.

5.1.2.2 The Impact of Cardiac Rehabilitation on Physical Function

After completing a 16-week CR program, renal patients in our study (Mr. A, Ms. B, and Mr. C) attained a final aerobic capacity level of 11.00, 10.30, and 6.70 METs respectively; which equated to a change of +4.30, +2.80, and +0.40 from baseline respectively. Clinical Practice Guidelines and the Ontario Cardiac Care Network Standards consider a 0.5 MET improvement over 3-6 months of CR as successful (CCN, 2002). Looking at our findings, 2 of the 3 participants demonstrated improvements in aerobic capacity well beyond those expected of the CVD population suggesting that persons with CKD may receive a clinically significant benefit from participating in this rehabilitative service. By extension, we could suggest these results are even more impressive for persons with the complex metabolic profiles and exercise/movement limitations, especially at the moderate- to vigorous-activity level.
Improvements in aerobic capacity have been identified as a desired outcome of CR (Grace et al., 2014) and represents a mechanism by which this rehabilitative model exerts much of its positive influence on health variables (i.e. glucose metabolism, physical function, BP regulation, muscle endurance) (Balady et al., 2007; Corrà et al., 2010; Taylor et al., 2004; Taylor, Unal, Critchley, & Capewell, 2006). Systematic reviews and meta-analyses have provided quantitative evidence for significant increases in aerobic capacity after participation in CR (Conn, Hafdahl, Moore, Nielsen, & Brown, 2009; Sandercock, Hurtado, & Cardoso, 2013; Swain, 2005). In an evaluation of 3,827 CR patients conducted by Sandercock and colleagues (2013), a mean improvement of 1.55 METs (95% CI: 1.21-1.89; \( p < 0.001 \)) was demonstrated among patients with heart disease enrolled in 31 CR programs (Sandercock et al., 2013). This change is both impressive and clinically important as it signifies the efficacy of CR as a therapeutic tool to improve aerobic capacity. Moreover, these results translate into a decrease in CV mortality – as quantified by VO_{2peak} – further adding to the benefit of participating in CR (Sandercock et al., 2013). Within Sandercock’s (2013) analysis, patients enrolled in CR can expect an improvement in cardiorespiratory fitness on average of 5.4 ml/kg/min (95% CI: 4.2-6.6), equating to a reduction in mortality between 16-54% (Sandercock et al., 2013). Kavanagh and colleagues (2003) found that each 1 ml/kg/min gain in VO_{2peak} was associated with a 10% reduction in cardiac mortality (Kavanagh et al., 2003), whereas Vanhees and colleagues (1995) found each 1% increase in VO_{2peak} was associated with a 2% reduction in mortality (Vanhees et al., 1995). When looking at MET levels, Myers and colleagues (2002) found that a 1.0-point increase in fitness was associated with a 12% decrease in mortality (Myers et al., 2002), whereas Dorn and colleagues (1999) found a 1 MET gain produced a 10% reduction in mortality in male MI patients (Dorn et al., 1999). Such changes in aerobic capacity, and subsequent mortality rates,
may be explained by the improvements in muscle strength and power gained by participating in CR.

Numerous physical function measures have been used to understand the changes in cardiorespiratory fitness gained from partaking in CR programs. Recently, a study conducted by Puthoff and colleagues (2013) quantified the MDC of STS measurements among cardiac patients enrolled in this rehabilitative service (Puthoff & Saskowski, 2013). This physical function assessment captures mobility and balance patterns in those with CVD, and is used to prescribe patients with the most appropriate exercise interventions. Within this study, a MDC of 3.12 seconds (ICC = 0.87; SEM = 1.12) for five STS was demonstrated among 49 inpatient and outpatient CR participants (Puthoff & Saskowski, 2013). Though this outcome is reliable for those with cardiac-related complications, no reliability data has been documented for those with CKD. In terms of our investigation, a different evaluation of STS was performed. Renal participants were asked to complete as many STS repetitions within a 30 second period; as contrasted to the time it takes to complete five repetitions. This version has demonstrated better reliability in community-dwelling older adults compared to the time required to complete five STS maneuvers (Bohannon, 2002), and has a quantified MDC\(_{95}\) for the renal population (i.e. MDC\(_{95}\) = 2.6 repetitions) (Overend et al., 2010). When looking at our participants, both Mr. A and Ms. B reached a clinically significant change in their functionality from baseline (+5.0 repetitions for Mr. A, and +4.0 repetitions for Ms. B); however, a non-significant decline was noticed in Mr. C (i.e. -1.7 repetitions). In order to understand these differences in findings, results need to be understood within the context of patients’ level of kidney function, social setting, alongside other hemodynamic factors. Previous investigations have demonstrated that eGFR and protein levels may contribute to changes in physical function among CKD populations.
Within a study conducted Odden and colleagues (2004), investigators concluded that decreased kidney function and anemia are independently associated with physical limitations and reduced exercise capacity among those with CKD (Odden, Whooley, & Shlipak, 2004). This is paralleled in recent work conducted by Hiraki and colleagues (2013), who demonstrated that handgrip strength, knee extensor muscle strength, single-leg stance time, and maximum gait speed all decreased alongside a reduction in eGFR (Hiraki et al., 2013). In terms of our investigation, Mr. C demonstrated a reduction in the number of STS repetitions they could complete within a 30-second time frame. Compared to baseline, this participant performed 1.7 fewer repetitions at discharge; equating to a reduction in physical function of approximately 10%. This result may be a consequence of their deteriorating kidney function. Upon the completion of the CR program, Mr. C’s eGFR decreased by 12.0 mL/min/1.73 m² (i.e. a movement from Stage 3b to Stage 4 CKD). Though not assessed within this study, this reduction may be caused by the pro-inflammatory state associated with deteriorating renal function; which is suspected to contribute to decreased lower extremity strength and physical function through a decrease in muscle mass (i.e. sarcopenia) (Fried et al., 2006; McIntyre et al., 2006). Foley and colleagues (2007) reported an association between increasing sarcopenia prevalence and declining GFR in community-dwelling adults (Foley, Wang, C., Ishani, Collins, & Murray, 2007). Furthermore, declining eGFR has been associated with protein wasting – especially within skeletal muscle – as a result of impaired protein synthesis and increased protein degradation (Kosmadakis et al., 2010). To determine whether these underlying factors led to a reduced physical function and associated deterioration in kidney function in Mr. C, additional measurements of muscle mass would be needed within our study.
5.1.2.3 The Effect of Cardiac Rehabilitation on Cardiovascular Disease Risk Factors

Upon completion of the CR program, all CKD subjects demonstrated an improvement in their serum glucose profiles. In terms of glycated hemoglobin, each participant neared the target value of ~7% at discharge (5.8%; 5.5%; 6.8%, respectively); whereas only Mr. A and Ms. B fell within the optimal range of FBS at discharge (5.6 mmol/L and 5.0 mmol/L, respectively; target = 4.0-6.0 mmol/L). These values differ slightly from other renal studies utilizing this rehabilitative service; however, clinically significant differences cannot be understood due to the few number of investigations conducted within this area.

To our knowledge, only one study has evaluated the impact of participating in CR on blood sugar profiles among pre-dialysis CKD patients (Völler et al., 2014). Within Völler and colleagues (2014) investigation, higher baseline values for glycated hemoglobin were reported (6.4 ± 1.1%; n=35,197) as compared to any of our CKD participants. In terms of FBS, both baseline and discharge measurements were slightly higher in Völler’s cohort (6.1 ± 1.2 mmol/L at baseline to 5.9 ± 1.6 mmol/L at discharge) as contrasted with data from our participants (Völler et al., 2014). Despite the slight differences in results, values from both blood sugar measurements suggest that improvements in serum glucose values are attained after completing a CR program; which may further explain improvements in kidney function associated with participation in this rehabilitative service. Patients within Völler’s (2014) study were able to maintain the same level of serum creatinine (i.e., 1.4 ± 1.1 mg/dL), whereby a stable pre- and post-value imply that eGFR did not change. When looking at our participants, both Mr. A and Ms. B maintained the same stage of CKD (i.e. Stage 4) after participating in CR. Contrastingly, Mr. C demonstrated a decrease in eGFR upon completion of the program, which may be explained by their increased fasting blood sugar value at discharge (i.e. 10.5 mmol/L; target = 4.0-6.0 mmol/L). Previous
research has shown that elevated serum glucose is linked to multiple metabolic perturbations including diminution nitric oxide production, activation of protein kinase C (PKC), accumulation of advanced glycosylated end-products, and increased prostaglandins; all of which reduce kidney function. Specifically, hyperglycemia activates isoforms of PKC, through diacylglycerol, which subsequently increases reactive oxygen species (ROS). Influxes in the amount of ROS further increases cytokines and extracellular membrane proteins type IV collagen leading to glomerulosclerosis and renal failure (Ohshiro, Lee, & King, 2005). Though our study did not quantify this biological mechanism, such processes may have influenced Mr. C’s deterioration in kidney function. Other modifications in serum profiles have also been attributed to the decline in eGFR, including decreases in HDL-C levels and increases in TG levels.

Previous literature has reported that abnormal lipid profiles (specifically TG and HDL-C levels) accelerate the progression of CKD (Harper & Jacobson, 2008; Abrass, 2006). In experimental studies using hyperlipidemic CKD mice, the mechanism by which dyslipidemia contributes to renal tissue injury may be caused by increasing ROS-induced activation of nuclear factor kappa B and subsequent elevation of interleukin-6 (Sharo, Kumagai, Yokota-Ikeda, Ito, & Ikeda, 2009; Scheuer et al., 2000). This specifically occurs within individuals who have elevated TG levels and low HDL-C levels. Within our study, Mr. C only demonstrated a reduction in HDL-C (i.e. 0.81 mmol/L at baseline to 0.79 mmol/L at discharge); whereas TG values improved (i.e. 4.29 mmol/L at baseline to 1.55 mmol/L at discharge). The slight decrease in HDL-C, however, is too small to suggest a causal deterioration in kidney function; suggesting that other factors may have contributed to its decline. During the course of the CR program, Mr. C experienced a significant life event (i.e. house fire) which may have resulted in added stress, decreased consumption of home-cooked meals, limited sleep, and other challenges relating to his
CKD. The collective effect of these elements may explain the change in CKD stage from 3b to 4; however, measurement of these factors was not captured within our study. When looking at the improvement in TG, this decrease may be explained by the positive effect of EXT on lipid values.

Previous studies enrolling renal patients in CR have shown significant reductions in TG values after completion of this rehabilitative service. In 2005, Venkataramen and colleagues (2005) compared baseline and discharge TG values for 115 CKD patients attending CR (Venkataramen et al., 2005). Upon completion of this hospital-based outpatient program, TG values decreased from 2.03 ± 1.35 mmol/L at baseline to 1.82 ± 1.00 mmol/L at discharge; representing an improvement greater than their non-CKD counterparts (i.e. 1.87 ± 1.00 mmol/L at discharge) (Venkataramen et al., 2005). These findings are consistent with previous studies providing EXT interventions to clinical populations (Scheuer et al., 2000), where decreases in TG are a common consequence of engaging in structured PA. Furthermore, renal literature has reported that decreases in serum TGs are significantly and negatively associated with improvements in eGFR after participation in EXT (r = -0.513, p = 0.025) (Toyama, Sugiyama, Oka, Sumida, & Ogawa, 2010). These findings are further supported within studies in nephritic rat models, where exercise has been shown to prevent progressive renal dysfunction through reductions in hyperlipidemia (Osata et al., 1990).

5.1.2.4 Modifications in Self-Management Behaviours

To our knowledge this is the first investigation to use the Life Options CKD Self-Management Survey in order to monitor changes in SM behaviours among a cohort of renal individuals participating in CR. Upon completion of our study, engagement in this 16-week rehabilitative service resulted in improvements among most of the CKD-specific SM domains.
When looking at Mr. A and Mr. C, specifically, both participants’ demonstrated an increase in the communication, partnership in care, and self-care constructs (Mr. A: 1.63 to 2.13, 1.43 to 2.71, 2.55 to 3.18; Mr. C: 1.38 to 2.13, 1.14 to 1.43, 3.27 to 3.55; respectively). Changes in the latter category (i.e. self-care) are of specific interest to our study as this construct: (a) is the “action” dimension of self-regulation taught within CR, supporting the improvement demonstrated and (b) demonstrates a change greater than any other renal study using this scale, suggesting that CR may provide an added benefit to impacting this dimension of SM.

In a cross-sectional survey (no intervention) conducted by Curtin and colleagues (2008), 174 patients with CKD (serum creatinine ≥1.7 mg/dL) demonstrated a mean item score of 2.73 on the self-care construct of the Life Options CKD Self-Management Survey (Curtin et al., 2008). This value represents a response between “a few times” (i.e. score of 2) and “a lot of the time” (i.e. score of 3). At minimum, participants in our case series reported a score of 2.55 within this domain at baseline; which subsequently increased to at least 3.09 at discharge. Such an improvement suggests that CR may be an efficacious SM program to educate patients with CKD on the importance of becoming self-managers of their condition. Inherently, this rehabilitative service is designed to enhance the acquisition of knowledge, encourage individuals to play an active and collaborative role in their disease management, reinforce systems for individualized psychological support, and improve adherence to positive health behaviours (Chen et al., 2011). Through participation in CR, persons with CKD in our study were able to identify the factors contributing to their health-related problems based on activities such as self-monitoring, systematic observation, and recording of their daily step counts. As a result, they may have come to realize that certain routines and behaviours – such as the consumption of an excessively salty or high-protein diet – influenced their CV and renal function, and thus tried to abstain from these
harmful practices on their own accord. When participants’ health status improved through the regulation of these behaviours, a positive feedback may have caused a subsequent increase in their confidence levels (as demonstrated by increased scores on the MSES). These results are of further interest as the education and skills provided within the CR program were not specific to those with CKD. The majority of education sessions pertained to vascular healthy activities, engaging in PA, and maintaining a healthy diet among those primarily with CVD. These findings suggest that generic CVD education can have a positive impact on CKD-specific SM behaviours. At a minimum, this infers that there is no negative SM burden created by participation in CR and may, if reinforced by data obtained through larger, prospective trial, improve access to services.

5.2 Limitations

In terms of this pilot study, there is limited external validity as the findings might not be transferable to a larger population of individuals with CKD. In order to provide statistically significant results, a prospective RCT is needed to provide clinically relevant findings for Phase II of the study, and a qualitative component of Phase I is needed to further characterize the barriers and facilitators to CR participation among patients with CKD.

5.2.1 Phase I: Recruitment

With respect to Phase I, a major limitation of our study was the fast-paced nature of the Nephrology Program from which recruitment took place. In this clinic, all patients are seen by four separate clinicians (nephrologist, nurse, dietitian, and social worker), in addition to having scheduled blood work, making interaction with potential participants challenging in this context.
Of those meeting inclusion criteria, 43.1% (n=115) were not seen by our research associate; representing a cohort that may have enrolled in the rehabilitation service. A second limitation of our study was the distance of the HDH-CRC from participants’ homes. Over 65% of individuals were commuting greater than an hour to their nephrology appointments at KGH (i.e. as far as Brockville in the east and Picton in the west), and could not commit to the additional twice-weekly on-site exercise sessions. In hopes of recruiting some of these patients with CKD, a few strategies could be undertaken within a future study: (a) have participants enroll in the Picton or Napanee CR sites or (b) allow those at low-risk for adverse events to be triaged into the off-site exercise group (i.e. EXT sessions are completed at participants’ local exercise facility rather than at the HDH-CRC; and measurements can be timed with participants’ Nephrology Program appointments). Lastly, the lack of active physician endorsement from nephrologists was another limitation of our study. Knowing practitioners’ busy schedules, the research associate took the primary role of recruiting patients; however, additional support may have improved the low accrual and retention rates.

5.2.2 Phase II: Case Series

With respect to Phase II, a major limitation of our study revolved around the methodological design. In the absence of an adequate number of study participants, we were limited in your ability to use parametric statistics to describe changes observed across the study (primarily because they violate assumptions underlying the use of those approaches) preventing us from demonstrating any statistically significant changes in our outcome measures. Secondly, in the absence of a control group we had no way of knowing if similar fluctuations in exercise SE
may have occurred across time among patients with CKD not engaged in CR. The primary benefit of our study was that it lends support to the argument that a prospective trial is worth the cost and reinforces that the MSES is a feasible tool within a CR context. There is also an argument against using a true sedentary control group; given the growing evidence about the dangers of a sedentary life. It will take some critical thinking and investigation to determine what the most appropriate control group would be for a future RCT. Lastly, participants weren’t blinded to the intervention (i.e. CR); however, this would likely be impossible to accomplish. The evaluators weren’t blinded either, but the use of standardized assessments and the fact that the GXTs were performed by individuals who were naïve about the study add weight to the assertion that our findings are genuine. Never-the-less, this work warrants replication in a methodologically more rigorous design.

5.3 Future Directions

Based on the findings of this exploratory investigation regarding the impact of CR on exercise SE among persons with CKD, two streams of future research are indicated. First, based on our findings in Phase I, there is a need to conduct a qualitative study among persons with CKD in order to explore the facilitators and barriers to CR enrollment among this population. Data from Phase II suggests that CR may be a powerful tool to impact exercise SE, aerobic capacity, and PA behaviour among those who attend; however, based on low recruitment and enrollment ratios, it suggests that further work is needed to understand how this rehabilitation service may best be designed to meet the needs of this clinical population. The use of participatory action research would be a helpful paradigm through which to explore the model of
CR for persons with CKD in a rural context. Further, future investigation should consider comparative evaluations of CR against other self-management models.

The second stream of potential future research would be to conduct a RCT of the CR paradigm on exercise SE, aerobic capacity, SM behaviours, and renal and metabolic outcomes among persons with CKD. In order to achieve a critical mass of participants, additional recruitment strategies are warranted and include the development of a coordinated endorsement of the project by all staff nephrologists, additional research associates/nurses to maximize recruitment, a long time-frame for recruitment, and the use of a multi-centre trial. The use of any or all of these strategies would provide the necessary documentation and protocols needed to ensure the success of a larger study, in addition to aiding in the sustainability of a RCT.

5.4 Conclusion

In summary, the utilization of CR among those with CKD is a complex entity that may be affected by multiple factors including age, gender, and proximity to the facility. Based on our results, there sufficient information to suggest that distance is a major barrier to the use of this health service. Given our low recruitment and enrollment ratios, it suggests that further work is needed to understand how this service may best be designed to meet the needs of our clinical population. The use of participatory action research may be a helpful paradigm through which to explore the model of CR for persons with CKD in a rural context. In terms of its impact on exercise SE, it is suggested that participation in CR leads to a general increase in confidence levels. This SM program may provide renal patients with the necessary sources of SE needed to improve their exercise confidence; which ultimately may translate into greater adherence to self-directed behaviours over the long-term. Whether this service is beneficial for a larger cohort is
not evident given our chosen study design or is superior to other models of Chronic Disease Self-management programs on the selected outcomes is unknown; hence, further research is needed.
References


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Daly, J., Sindone, A. P., Thompson, D. R., Hancock, K., Chang, E., & Davidson, P. (2002). Barriers to participation in and adherence to cardiac rehabilitation programs: a critical literature review. *Progress in Cardiovascular Nursing*, 17(1), 8-17.


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## Appendix A: Timeline of Outcome Measures

<table>
<thead>
<tr>
<th>Prior to Starting Cardiac Rehabilitation</th>
<th>Outcome Measure</th>
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</table>
| **Week -2** | • Blood measurements: glucose [glycated hemoglobin, fasting blood sugar] and lipid [high-density lipoprotein cholesterol, low-density lipoprotein cholesterol, total cholesterol/high-density lipoprotein cholesterol, triglycerides, total cholesterol] profiles  
• Kidney function [serum creatinine]  
• Peak aerobic capacity [metabolic equivalents]  
• Blood pressure and heart rate  
• Anthropometrics: weight, height, BMI, and waist circumference  
• Physical activity behaviour [pedometer]  
• Self-management behaviour [*Life Options CKD Self-Management Survey*] |
| **Week -1** | • Exercise SE [*Multidimensional Self-Efficacy for Exercise Scale*]  
• Functional balance [Berg Balance Scale]  
• Lower extremity function [30-second Chair Stand Test]  
• Lower extremity power [Stair Climb Test] |

### During Cardiac Rehabilitation

<table>
<thead>
<tr>
<th>Week Measured</th>
<th>Outcome Measure</th>
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<tbody>
<tr>
<td><strong>Weeks 4, 8, and 12</strong></td>
<td>• Exercise SE [<em>Multidimensional Self-Efficacy for Exercise Scale</em>]</td>
</tr>
</tbody>
</table>
| **Weeks 14 and/or 15** | • Blood measurements: glucose [glycated hemoglobin, fasting blood sugar] and lipid [high-density lipoprotein cholesterol, low-density lipoprotein cholesterol, total cholesterol/high-density lipoprotein cholesterol, triglycerides, total cholesterol] profiles  
• Glucose and lipid profiles, and creatinine  
• Kidney function [serum creatinine]  
• Anthropometrics: weight, height, BMI, and waist circumference  
• Peak aerobic capacity [metabolic equivalents]  
• Blood pressure and heart rate  
• Anthropometrics: weight, height, and waist circumference  
• Physical activity behaviour [pedometer]  
• SM behaviour [*Life Options CKD Self-Management Survey*]  
• Functional balance [Berg Balance Scale]*  
• Lower extremity function [30-second Chair Stand Test]*  
• Lower extremity power [Stair Climb Test] * |
| **Week 16** | • Exercise SE [*Multidimensional Self-Efficacy for Exercise Scale*] |

* Physical function measurements were taken on a separate day as not to be influenced by exercise training effects
# Appendix B: Chart Abstraction Form

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<th>Contact Info</th>
<th>FFU</th>
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<th>Did’t see</th>
<th>Based on CKD Stage</th>
<th>MO FILE</th>
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## Demographics

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<th>Postal Code</th>
<th>CKD Stage</th>
<th>Obesity</th>
<th>HTN</th>
<th>High blood cholesterol</th>
<th>Diabetes or prediabetes</th>
<th>Anemia</th>
<th>Alcohol abuse</th>
<th>Cognitive or developmental delay</th>
<th>Physical activity</th>
<th>Musculoskeletal impairment</th>
<th>Cognitive or behavioural condition</th>
<th>Use of wheelchair or assistive walking device</th>
<th>Visual condition</th>
<th>Neurological condition</th>
<th>&lt;5 METs on GXT</th>
<th>Previous participation in CRC</th>
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## Inclusion Criteria

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## Exclusion Criteria

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<tr>
<th>Unstable angina</th>
<th>Orthostatic BP decrease &gt; 20 mmHg</th>
<th>Hypertrophic obstructive cardiomyopathy</th>
<th>Musculoskeletal impairment</th>
<th>Cognitive or behavioural condition</th>
<th>Use of wheelchair or assistive walking device</th>
<th>Vision condition</th>
<th>Neurological condition</th>
<th>&lt;5 METs on GXT</th>
<th>Previous participation in CRC</th>
<th>Comments</th>
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</table>

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### Appendix C: Inclusion and Exclusion Criteria

<table>
<thead>
<tr>
<th>Inclusion Criteria</th>
<th>Exclusion Criteria</th>
</tr>
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<tbody>
<tr>
<td>• Diagnosed with Stages 3-4 chronic kidney disease (i.e. estimated glomerular filtration rate less than 60 mL/min/1.73 m²)</td>
<td>• Active alcoholic abuse</td>
</tr>
<tr>
<td>• Over the age of 18</td>
<td>• Diagnosed developmental delay</td>
</tr>
<tr>
<td>• Have more than one of the following conditions: <strong>overweight</strong> (body mass index above 25.0), <strong>hypertension</strong> (defined as: systolic blood pressure at or above 140 mmHg and/or a diastolic blood pressure at or above 90 mmHg for non-diabetics; or systolic blood pressure at or above 130 mmHg and/or a diastolic blood pressure at or above 80 mmHg for diabetics), <strong>high total cholesterol</strong> (defined as ≥ 6.20 mmol/L), <strong>diabetes</strong> (defined as: fasting plasma glucose ≥ 7.0 mmol/L; glycated hemoglobin ≥ 6.5%; 2-hour plasma glucose in a 75 g oral glucose tolerance test ≥ 11.1 mmol/L; or random plasma glucose ≥ 11.1 mmol/L) or <strong>pre-diabetes</strong> (defined as: fasting plasma glucose 6.1–6.9 mmol/L; glycated hemoglobin 6.0–6.4%; or 2-hour plasma glucose 75 g oral glucose tolerance test 7.8–11.0 mmol/L; or), and/or you have <strong>anemia</strong> (defined as: hemoglobin levels &lt; 7.4 mmol/L for non-pregnant, women over the age of 15; or &lt; 8.1 mmol/L for men over the age of 15).</td>
<td>• Morbid obesity (body mass index ≥ 35 kg/m²)</td>
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<tr>
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<td>• Resting blood pressure greater than 200/100 mmHg despite medication</td>
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<tr>
<td>• Ability to understand the process and instructions for exercise training and provide informed consent (accomplished at the time of recruitment and during the consent process)</td>
<td>• Unstable angina</td>
</tr>
<tr>
<td>• Able to complete the graded exercise tolerance test and peak aerobic capacity measure</td>
<td>• Orthostatic blood pressure decrease of &gt; 20 mmHg with symptoms</td>
</tr>
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<td>• Hypertrophic obstructive cardiomyopathy</td>
</tr>
<tr>
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<td>• Other musculoskeletal impairments which would limit the participant's ability to walk sufficient durations (e.g. spinal stenosis, rheumatoid arthritis)</td>
</tr>
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<td></td>
<td>• Cognitive and/or behavioural issues that would limit participation in exercise testing and training (e.g. schizophrenia, memory loss)</td>
</tr>
<tr>
<td></td>
<td>• Use of a wheelchair or other assistive walking device</td>
</tr>
<tr>
<td></td>
<td>• Visual or neurological conditions which would preclude participation (e.g. Parkinson’s, seizure disorder, macular degeneration, legally blind)</td>
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<tr>
<td></td>
<td>• A metabolic equivalent of less than 3 on the graded exercise tolerance test</td>
</tr>
<tr>
<td></td>
<td>• Completed the cardiac rehabilitation program at Hotel Dieu Hospital within 12 months of recruitment</td>
</tr>
<tr>
<td></td>
<td>• Other cardiovascular disease morbidity which would limit exercise tolerance (i.e. heart failure, abnormal blood pressure responses or ST-segment depression &gt; 2 mm, symptomatic aortic stenosis, complex arrhythmias, morbid obesity)</td>
</tr>
<tr>
<td></td>
<td>• Pain or other co-morbidities (e.g. unclipped aneurysms, uncontrolled seizures) which would preclude participation</td>
</tr>
</tbody>
</table>
Appendix D: Cardiac Rehabilitation Referral Form

Cardiac Rehabilitation Centre Referral

Telephone: 613-544-3400 Ext. 3123
Fax: 613-544-4749
Internet: www.hoteldieu.com

Health Card #
CR#: 
Patient Name: 
Date of Birth (yyyy/mm/dd): 
Address: 
Postal Code: 
Phone - Home: - Work: 

Primary Diagnosis: 
☐ Cardiac Surgery
☐ Percutaneous Coronary Intervention (PCI)
☐ Myocardial Infarction (MI)
☐ Acute Coronary Syndrome (ACS)
☐ Stable Coronary Artery Disease (CAD)
☐ Other Cardiovascular Insufficiency: ______________________________
☐ 3 or more Cardiovascular Risk Factors: _________________________

Cardiovascular diagnosis/event date (yyyy/mm/dd): _______________________

Diabetes Status: 
☐ Non Diabetic
☐ Diabetic

Baseline Functional Status: 
☐ Limited
☐ Active
☐ Athletic

Comments: 

Referring Practitioner Signature: ________________________________
Referring Practitioner Printed Name: _______________________________
Referral Date (yyyy/mm/dd): ________________________________

Your patient will be assessed in a SCREENING CLINIC by an interdisciplinary team, including a cardiologist, to determine his/her suitability for the Cardiac Rehabilitation Centre’s (CRC) services. Upon admission, your patient will receive the following services at the CRC:

• An individually prescribed and monitored graduated exercise program.
• Education classes in risk factor modification in the physical, psychosocial and nutritional areas.
• Access to dedicated time with a physiotherapist, dietitian, social work, cardiovascular nurse and/or cardiologist as appropriate.

Mail or FAX Referral to the Cardiac Rehab Centre Clinic - Fax # 613-544-4749

Please advise patients that they will:

• Be contacted by the Hospital with the appointment date and time.
• Need to bring their health card and medications with them.
Appendix E: Informed Consent Form

DETERMINING THE IMPACT OF THE CARDIAC REHABILITATION PARADIGM ON ARTERIAL STIFFNESS, CARDIOVASCULAR DISEASE RISK FACTORS, AND SELF-EFFICACY IN PRE-DIALYSIS CHRONIC KIDNEY DISEASE PATIENTS (REH-538-12)

Invitation to Participate
You are invited to participate in a research study in which you will be asked to participate in a 16-week Cardiac Rehabilitation program available through the Hotel Dieu Hospital Cardiac Rehabilitation Centre in Kingston, ON.

Basis for Subject Selection
The reason you are being asked to participate in this study is because you are 18 years of age or older, have been diagnosed with chronic kidney disease, and have more than one of the following conditions: overweight, high blood pressure, high cholesterol, diabetes or pre-diabetes, and/or anemia. We are asking you to participate in a pilot study in order to determine the feasibility of the study protocol. In order to accomplish this purpose, we are recruiting volunteers to participate in this study who will be assigned to either a “Cardiac Rehabilitation Group (Group A)” or a “Usual Care Group (Group B)”.

Purpose of the Study
The overall purpose of this study is to assess whether or not a Cardiac Rehabilitation program can help to: lower arterial stiffness, improve one’s cardiac disease risk factor profile (having high blood pressure, being overweight, being physically inactive, having a poor diet, having high stress), and/or slow the progression of chronic kidney disease.

Explanation of Procedures
You are being asked to participate in a 16-week study where you will be randomly placed into either “Group A (Cardiac Rehabilitation)” or “Group B (Usual Care)”.

If you are assigned to “Group A (Cardiac Rehabilitation)”, you will be given the opportunity to participate in a 16-week Cardiac Rehabilitation program delivered through the Hotel Dieu Hospital Cardiac Rehabilitation Centre. This Cardiac Rehabilitation program will include:

• A screening clinic assessment and thorough review of your cardiac disease risk factor profile;
• Consultations with a physiotherapist, a cardiac nurse, a cardiologist, and a dietician;
• An on-site exercise program (2 days/week for 16 weeks);
• Advice on doing a home-based exercise program (1 day/week for 16 weeks); and
• An education program where you will learn about all the aspects of cardiovascular disease prevention and management (1 day/week for 12 weeks).

The on-site exercise sessions will be 1.5 hours in length (3 hours/week). The education classes will be 1.5 hours in length (1.5 hours/week).
If you are assigned to “Group B (Usual Care)” you will receive your usual care from your nephrology team and will be asked to attend the Hotel Dieu Hospital Cardiac Rehabilitation Centre Screening Clinic, where you will meet with a physiotherapist, a cardiac nurse, a cardiologist, and a dietician. At the Screening Clinic you will be asked to undergo an assessment and thorough review of your cardiac disease risk factor profile. Following the 16 weeks of your usual care and completion of your follow-up measurement appointments, you will be offered the opportunity to participate in the Cardiac Rehabilitation program, if you so wish.

Regardless of the group you are assigned to (Group A or Group B), you will be asked to perform the outcome measures listed below before the start of the study and immediately upon completion of the 16-week study. These measures are included to: (a) provide information to the healthcare team to determine whether or not it is safe for you to participate in a exercise program; and/or (b) to see if the Cardiac Rehabilitation program results in meaningful improvements in any of the following:

a) Scheduled by the Cardiac Rehabilitation Centre at Hotel Dieu Hospital:
   i. **Blood Work** (30 minutes) – in addition to your routine blood work done through the nephrology clinic, you will be asked for an additional blood sample.
   ii. **Exercise Test** (45 minutes) – you will be asked to undergo a graded exercise test in order to determine your peak aerobic fitness (i.e., your ability to work for long periods of time). This test will be conducted at the Hotel Dieu Hospital in the clinical exercise testing facility.

b) Completed at the Hotel Dieu Hospital Cardiac Rehabilitation Centre:
   i. **Physical Function Tests** (30 minutes):
      - **Sit to Stand Test** (5 minutes) – you will be asked to stand up from a seated position as many times as you can in 30 seconds, using a standard chair without armrests. The number of complete sit-to-stand cycles that you perform is used to tell us about the strength of your legs.
      - **Berg Balance Scale Test** (15 minutes) – this functional test will ask you to carry out 14 simple tasks to assess your balance and risk of falls.
      - **Stair climb test** (10 minutes) – you will be asked to climb a single flight of stairs (10 steps) as fast and safely as you can. The time it takes for you to climb the steps will be recorded.
   ii. **Resting blood pressure, heart rate, and arterial stiffness** (20 minutes) – your blood pressure and heart rate will be measured using an automated office blood pressure device (BpTRU). You will be asked to sit alone in a quiet room. The device will automatically take blood pressure measures at 1 or 2 minute intervals for six measures in total. Immediately after the blood pressure readings, you will have a test to check the stiffness of the arteries in your arm and leg. A NON-INVASIVE ‘pencil-like’, hand-held probe will be placed on your neck (carotid artery) and upper part of your leg (femoral artery) at the points of your strongest pulse. You will be asked to keep as still as possible during the test for each site – we will need to obtain a series 10 good consecutive wave forms which is the equivalent of 10 heart beats.
iii. **Body weight, body height, and waist and hip circumference** (10 minutes) – your body weight and height will be measured using standard equipment in the *Hotel Dieu Cardiac Rehabilitation Centre*. Your waist and hip circumference will be measured by a research associate using a tape measure.

c) Completed on your own *at home*:

i. **Multidimensional Self-Efficacy Exercise Scale** (10 minutes) – this questionnaire will ask you 9 questions about your confidence in completing, scheduling, and coping with a structured exercise program. At the beginning and end of the study, you will be asked to return the questionnaire to a research associate.

ii. **Life Options’ Chronic Kidney Disease Self-management and Self-Efficacy Survey** (45 minutes) – this questionnaire will ask you 59 questions about your attitudes, behaviours, and confidence regarding the self-management of your chronic kidney disease. At the beginning and end of the study, you will be asked to return the questionnaire to a research associate.

iii. **Pedometers** (7 days) – you will be asked to wear a small device (i.e., pedometer) – on the waistband of your pants – for one week during your waking hours. This device will count the total number of steps you take in a day, which you will record for one week in a logbook that will be provided to you. At the beginning and end of the study, you will be asked to return the pedometer to a research associate.

*Other Information:*

We are also asking for your consent to have access to the medical documentation recorded by the *Hotel Dieu Hospital Cardiac Rehabilitation Centre* and the *Kingston General Hospital Nephrology Program* in order to confirm the following information: your age, sex, general health history, your primary kidney diagnosis, whether or not you have any other chronic health conditions, your medication history, and the results of your *Hotel Dieu Hospital Cardiac Rehabilitation Centre* Screening Clinic and program participation data.

*Potential Risks and Discomfort*

The graded exercise treadmill test carries with it a small risk of an acute cardiovascular event, such as a heart attack or sudden cardiac death. In a mixed population, the risk of an adverse event with exercise testing is approximately 6 cardiac events per 10,000 symptom-limited maximum tests. The absolute risk of sudden cardiac death during vigorous physical activity has been estimated at 1 per year for every 15,000 to 18,000 individuals. This risk is reduced by:

- Appropriate medical screening prior to the start of the test (i.e. your health history is reviewed to determine if you have any contra-indications to testing);
- Careful monitoring throughout the test by trained medical staff (i.e. the clinical team at *Hotel Dieu Hospital*); and
- The availability of emergency response equipment and procedures should an event occur. The mortality rate has been shown to be 6 times lower when patients exercise in facilities with the ability to successfully manage cardiac arrest.
During the exercise program, you may feel discomfort and muscle fatigue/soreness. If you have an existing heart condition, there is a small chance that a cardiac event may occur. This risk has been estimated to be 1 cardiac arrest per 116,906 patient-hours, 1 myocardial infarction per 219,970 patient-hours, and 1 fatality per 752,365 patient-hours. The mortality rate appears to be 6 times higher when patients exercise in facilities without the ability to successfully manage cardiac arrest. As such, this risk will be minimized by a thorough pre-exercise screening assessment by the Cardiac Rehabilitation team at Hotel Dieu Hospital in order to ensure your suitability for the program. Furthermore, exercises will be started at a low intensity and carefully monitored by trained personnel. All on-site exercise sessions will be supervised by a physiotherapist, nurse, and/or cardiologist to ensure your comfort and safety. Any medical emergency will be handled through the normal policy and procedures of the Hotel Dieu Hospital Cardiac Rehabilitation Centre.

During the process of filling out the Multidimensional Self-Efficacy Exercise Scale or Life Options’ Chronic Kidney Disease Self-management and Self-Efficacy Survey, you may potentially feel emotionally troubled when reflecting on your health. We encourage you to discuss any issues that arise with the study investigators and attending medical, physiotherapy, and/or nursing staff.

**Potential Benefits**

Your participation in this study will afford you the opportunity to participate in a Cardiac Rehabilitation Program (either immediately or following 16-weeks). Cardiac Rehabilitation is considered the standard management for so-called “cardio-metabolic diseases”, which include heart disease and diabetes. It is anticipated that participants in this program will experience improvements in their cardiovascular health (i.e., decrease stiffness in their arteries), functional capacities (i.e. how far they can walk), body weight, waist circumference, and overall quality of life.

Furthermore, your participation in this study will provide researchers with valuable preliminary information in order to guide the development of future investigations and to support the application for funding from the Canadian Institutes of Health Research. Ultimately, the results of this study will inform the practice patterns of healthcare providers who work with individuals with chronic kidney disease.

**Financial Obligations**

Participants will be expected to make their own travel arrangements to the Hotel Dieu Hospital Cardiac Rehabilitation Centre in order to participate in the on-site assessments (i.e., exercise training, education sessions, and outcome measures).

**Assurance of Confidentiality**

Any information obtained in connection with this study will be held in strict confidence. Each participant will be assigned a code, known only to the investigators. The data containing your results will be available on an Excel spreadsheet using only your participant code. Any identifying information (i.e. the code sheet listing participant names and associated code) will be kept in a locked file cabinet in Dr. Parsons’ office at Queen’s University (Louise D. Acton building). Only the investigators of this study will have access to this information.
Withdrawal from Study
Participation is voluntary. You are free to withdraw your consent and to discontinue participation at any time, even if the study has started. If you decline to participate this does not affect your relationship with Kingston General Hospital or Hotel Dieu Hospital.

Offer to Answer Questions
If you have any questions, please do not hesitate to contact Kasha Pyka, the Masters candidate involved with the study, or Dr. Trisha Parsons, the Principal Investigator of the study, at (613) 533-2640.

If you have any concerns regarding the student’s authorization to perform this study you may also contact Dr. Marcia Finlayson, the Director at the School of Rehabilitation Therapy & Vice Dean of Health Sciences, at (613) 533-2576.

If you have any concerns about your rights as a research participant, please contact Dr. Albert Clark, Chair of the Queen’s University Health Sciences and Affiliated Teaching Hospitals Research Ethics Board, at (613) 533-6081.

YOU ARE VOLUNTARILY MAKING A DECISION WHETHER OR NOT TO PARTICIPATE IN THIS RESEARCH STUDY. YOUR SIGNATURE CERTIFIES THAT YOU HAVE DECIDED TO PARTICIPATE HAVING READ AND UNDERSTOOD THE INFORMATION PRESENTED. YOUR SIGNATURE ALSO CERTIFIES THAT YOU HAVE HAD AN ADEQUATE OPPORTUNITY TO DISCUSS THIS STUDY WITH THE INVESTIGATOR(S) AND YOU HAVE HAD ALL OF YOUR QUESTIONS ANSWERED TO YOUR SATISFACTION. YOU WILL RECEIVE A COPY OF THIS CONSENT FORM TO KEEP.

______________________________  ______________________
Signature of Participant           Date

IN MY JUDGEMENT, THE PARTICIPANT IS VOLUNTARILY AND IS KNOWINGLY PROVIDING INFORMED CONSENT AND POSSESSES THE LEGAL CAPACITY TO GIVE INFORMED CONSENT TO PARTICIPATE IN THIS RESEARCH STUDY.

______________________________  ______________________
Signature of Investigator           Date
<table>
<thead>
<tr>
<th>Principal Investigator:</th>
<th>Student Investigator:</th>
</tr>
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<tbody>
<tr>
<td>Dr. Trisha L. Parsons</td>
<td>Ms. Kasha Pyka</td>
</tr>
<tr>
<td>BScPT, PhD (Rehabilitation Science)</td>
<td>MSc (Rehabilitation Science) Candidate</td>
</tr>
<tr>
<td>31 George Street, Louise D. Acton Building</td>
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<tr>
<td>School of Rehabilitation Therapy</td>
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<td>Queen’s University</td>
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<td>Kingston, ON, K7L3N6</td>
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<td>Tel: (613) 533-2640</td>
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<td>E-mail: <a href="mailto:parsonst@queensu.ca">parsonst@queensu.ca</a></td>
<td>E-mail: <a href="mailto:12KP20@queensu.ca">12KP20@queensu.ca</a></td>
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<thead>
<tr>
<th>Co-investigator</th>
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<tr>
<td>Prof. Diana Hopkins-Rosseel</td>
<td>Dr. Stephen LaHaye</td>
</tr>
<tr>
<td>D.E.C., B.Sc.(PT), M.Sc.(Rehab. Sci.), Clinical Specialist (CRPT) Professor</td>
<td>Cardiologist and Assistant Professor</td>
</tr>
<tr>
<td>School of Rehabilitation Therapy, Queen's University</td>
<td>Cardiac Rehabilitation Centre, Hotel Dieu Hospital</td>
</tr>
<tr>
<td>Kingston, Ontario</td>
<td>Queen’s University, Kingston, ON</td>
</tr>
<tr>
<td>Tel: 613-533-6096</td>
<td>E-mail: <a href="mailto:lahayes@KGH.KARI.NET">lahayes@KGH.KARI.NET</a></td>
</tr>
<tr>
<td>Email: <a href="mailto:hopkinsd@queensu.ca">hopkinsd@queensu.ca</a></td>
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<tr>
<td>Dr. Sunita Mathur</td>
<td>Dr. Jocelyn Garland</td>
</tr>
<tr>
<td>Dept of Physical Therapy</td>
<td>Clinical Nephrologist and Assistant Professor</td>
</tr>
<tr>
<td>University of Toronto</td>
<td>Division of Nephrology, Kingston General Hospital</td>
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<td>Kingston, ON</td>
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<tr>
<td>Tel: (416) 978-7761</td>
<td>Tel: (613) 533-3207</td>
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<tr>
<td>E-mail: <a href="mailto:sunita.mathur@utoronto.ca">sunita.mathur@utoronto.ca</a></td>
<td>E-mail: <a href="mailto:garlandj@queensu.ca">garlandj@queensu.ca</a></td>
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<td>Dr. Dina Brooks</td>
<td>Ms. Wilma Hopman</td>
</tr>
<tr>
<td>Professor</td>
<td>Biostatistician</td>
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<tr>
<td>Dept of Physical Therapy, University of Toronto</td>
<td>Queen’s University, Community Health and Epidemiology</td>
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<tr>
<td>Toronto, ON</td>
<td>Tel: (613) 549-6666 x814941</td>
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<td>E-mail: <a href="mailto:dina.brooks@utoronto.ca">dina.brooks@utoronto.ca</a></td>
<td>E-mail: <a href="mailto:hopmanw@KGH.KARI.NET">hopmanw@KGH.KARI.NET</a></td>
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Appendix F: The Risk of Activity Related Events (RARE) Score

Appendix G: Algorithm of Cardiac Rehabilitation Centre Usual Care

**System Algorithm**

**Initial Contact**
Referral
(Secretary)

**Pre-screening**
(Secretary/RN/PT)

- Meets criteria to be assessed in Screening Clinic
  - Secretary books Screening Clinic Appt.
  - 2 weeks prior to Screening Clinic to order/complete blood work and GXT
  - 1 week prior to Screening Clinic
    - Print relevant medical records
    - Check chart contents
      (Secretary)

- Does not meet criteria to be assessed in Screening Clinic
  - Leaves the System
    (referrals to other services as appropriate)

**Screening Clinic (SC)**
( Clients to bring medications)
Cardiologist, RN, PT History & Physical Ax
Self-administered questionnaires completed
(STOP-D, DASI, Self-efficacy x2, PHQ-9)
Dietitian review of medical records/blood work
Social Worker review of psychosocial questionnaires

**Client SC Interventions**
MD: Education on current status, prescribes medication changes & further testing
RN: Education on CRC services and process
PT: Education regarding physical status (fitness)
Consent to access medical records signed

**Assigned tasks:**
- 3-day food diary, logbook review, personal goal setting, daily pedometry & walking Rx
Client Rounds
Same day, post-SC, includes risk triage procedure
(all team members present, clients not in attendance)

Does Meet Admission Criteria
Does Not Meet Admission Criteria

Recommendation Meeting
(client and family group mtg.)
Review of CV risk factors
Consents signed
Letters to referral source, family MD, specialists

Leaves the system
(1) Recommendations to client
(2) letters to referral source, family MD, specialists
(3) referrals to other appropriate services

Education
Scheduled
(weekly large group)

Short term Exercise Risk Triage
Exercise Component Assigned
On-site / Off-site
(low/mod or high risk)

Individual Counselling Decisions
Appointments made with relevant team members
Dietitian, Social Worker, . . .

Prescriptions Made, Documented & Initiated
(exercise, activity, dietary, psychosocial)

Monitoring / Re-assessments
Multidisciplinary Rounds (q2wks)
Interim interactions with family MD, specialists as appropriate
(3 - 5 months)

Discharge Planning
GXT, blood work, questionnaires, 3 day food diary, goal setting, maintenance plan
All appropriate disciplines schedule D/C appt

Discharge Session(s)
(All disciplines input / PT reassesses and counsels)
Prescriptions / Referrals as appropriate

Leaves the System
(@ 4 - 6 months)
Letter to family MD, specialists

(Annual Potluck)
Appendix H: Warm-up Exercise Routine

Cardiac Rehabilitation Centre
Hotel Dieu Hospital
166 Brock Street,
Kingston, Ontario
K7L 5G2

Warm-Up Exercise Routine

Note: The cardiovascular warm-up should be approximately 5 to 8 minutes in duration.
(Approximately 8 – 10 repetitions of each exercise)

Legs:
1. March on the spot
2. Side stepping
3. Leg lifts to the back, one side at a time (i.e. not alternating)
4. Leg lifts to the side, alternating legs
5. Squats (you may substitute lunges for this exercise)
6. Knee lifts (marching with high knees, knees slightly out to the side)

Trunk:
1. Side bends alternating sides
2. Trunk twists (keep head forward)

Arms:
1. Punching (arm extensions) forward arms parallel to the floor
2. Punching to the sides
3. Punching up (towards the ceiling)
4. Arm circles clockwise
5. Arm circles counter-clockwise
6. Small diameter arm circles clockwise
7. Small diameter arm circles counter-clockwise

Arms and Legs:
Repeat the arm exercises 1 to 7 above while marching on the spot

Stretches:
1. Shoulders (reach across to opposite shoulder and hold elbow with other hand)
2. Arm underneath & arm over top (try touching finger tips together)
3. Chest stretch (arms open wide; wrists relaxed)

REMEMBER:
Each exercise should be repeated a minimum of 8 repetitions on each side.
The slower you move, the harder it is for the muscles – this is good; so please, move slowly.
Appendix I: Rating of Perceived Exertion (RPE)

RPE SCALE

0  Nothing at all
0.5 Very, very little
1  Very little
2  Little
3  Moderate
4  Somewhat strong
5  Strong
6  
7  Very strong
8  
9  
10 Very, very strong

… Maximal
Appendix J: Exercise Diary

Home Exercise Record

<table>
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<tr>
<th>Date</th>
<th>Type of aerobic exercise</th>
<th>Resting HR, RPE</th>
<th>Peak HR, RPE</th>
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HR = Heart rate; RPE = Rating of perceived exertion.

Daily Walking Record

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<th>Pre-walk HR</th>
<th>Peak HR</th>
<th>Waking duration</th>
<th>Symptoms/ mood</th>
<th>Total steps/day</th>
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HR = Heart rate.
Appendix K: Hotel Dieu Hospital Graded Exercise Tolerance Test Ramp Protocol

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Appendix L: Indications for Terminating Exercise Testing

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<td>• Drop in systolic blood pressure $\geq 10$ mmHg with an increase in work rate, or if systolic blood pressure decreases below the value obtained in the same position prior to testing when accompanied by other evidence of ischemia</td>
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<tr>
<td>• Moderately severe angina (defined as 3 on standard scale)</td>
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<tr>
<td>• Increasing nervous system symptoms (e.g. ataxia, dizziness, or near syncope)</td>
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<tr>
<td>• Signs of poor perfusion (cyanosis or pallor)</td>
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<tr>
<td>• Technical difficulties monitoring the electrocardiogram or systolic blood pressure</td>
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<td>• Subject’s desire to stop</td>
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<tr>
<td>• Sustained ventricular tachycardia</td>
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<tr>
<td>• ST elevation (+ 1.0 mm) in leads without diagnostic Q waves (other than chest lead I, or augmented voltage right)</td>
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<td>• Drop in systolic blood pressure $\geq 10$ mmHg with an increase in work rate, or if systolic blood pressure decreases below the value obtained in the same position prior to testing</td>
</tr>
<tr>
<td>• ST or QRS changes such as excessive ST depression (&gt; 2 mm horizontal or down sloping ST-segment depression) or marked axis shift</td>
</tr>
<tr>
<td>• Arrhythmias other than sustained ventricular tachycardia, including multifocal premature ventricular contraction, triplets of premature ventricular contractions, supraventricular tachycardia, heart block, or bradyarrhythmias</td>
</tr>
<tr>
<td>• Fatigue, shortness of breath, wheezing, leg cramps, or claudication</td>
</tr>
<tr>
<td>• Development of bundle-branch block or intraventricular conduction delay that cannot be distinguished from ventricular tachycardia</td>
</tr>
<tr>
<td>• Increasing chest pain</td>
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<tr>
<td>• Hypertensive response (systolic blood pressure of $&gt;250$ mmHg and/or a diastolic of $&gt;115$ mmHg)</td>
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Appendix M: Sample Education Schedule

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<td>Auditorium-Johnson 1</td>
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<td>11:30 - 12:30</td>
<td>Circle of Support</td>
<td>CRC – MEETING ROOM</td>
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<td>FEB 6</td>
<td>1:00 - 2:30</td>
<td>The Heart</td>
<td>Auditorium-Johnson 1</td>
</tr>
<tr>
<td>FEB 13</td>
<td>1:00 - 2:30</td>
<td>Exercise &amp; Activity 1</td>
<td>Auditorium-Johnson 1</td>
</tr>
<tr>
<td>FEB 20</td>
<td>1:00 - 2:30</td>
<td>Exercise &amp; Activity 2</td>
<td>Auditorium-Johnson 1</td>
</tr>
<tr>
<td>FEB 27</td>
<td></td>
<td><strong>NO EDUCATION SESSION</strong></td>
<td></td>
</tr>
<tr>
<td>MAR 6</td>
<td>1:00 - 2:30</td>
<td>Exercise &amp; Activity 3</td>
<td>Auditorium-Johnson 1</td>
</tr>
<tr>
<td>MAR 13</td>
<td>1:00 - 2:30</td>
<td>Stress Management 1</td>
<td>Auditorium-Johnson 1</td>
</tr>
<tr>
<td>MAR 20</td>
<td>1:00 - 2:30</td>
<td>Stress Management 2</td>
<td>Auditorium-Johnson 1</td>
</tr>
<tr>
<td>MAR 27</td>
<td>1:00 - 2:30</td>
<td>Stress Management 3</td>
<td>Auditorium-Johnson 1</td>
</tr>
<tr>
<td>APR 3</td>
<td></td>
<td><strong>NO EDUCATION SESSION</strong></td>
<td></td>
</tr>
<tr>
<td>APR 10</td>
<td>1:00 - 2:30</td>
<td>Nutrition 1</td>
<td>Auditorium-Johnson 1</td>
</tr>
<tr>
<td>APR 17</td>
<td>1:00 - 2:30</td>
<td>Nutrition 2</td>
<td>Auditorium-Johnson 1</td>
</tr>
<tr>
<td>APR 24</td>
<td>1:00 - 2:30</td>
<td>Nutrition 3</td>
<td>Auditorium-Johnson 1</td>
</tr>
</tbody>
</table>

CRC = Cardiac Rehabilitation Center
Appendix N: Multidimensional Self-Efficacy for Exercise Scale

Participant ID: _________  Date: _________

Time: ☐ Rec Meeting ☐ 1 ☐ 2 ☐ 3 ☐ Discharge ☐ 1-month post

<table>
<thead>
<tr>
<th>Multi-dimensional Self-Efficacy for Exercise Scale</th>
</tr>
</thead>
</table>

Please indicate HOW CONFIDENT YOU ARE THAT YOU CAN PERFORM the exercise assigned?

<table>
<thead>
<tr>
<th>%</th>
<th>0%</th>
<th>10%</th>
<th>20%</th>
<th>30%</th>
<th>40%</th>
<th>50%</th>
<th>60%</th>
<th>70%</th>
<th>80%</th>
<th>90%</th>
<th>100%</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Confidence</td>
<td>Complete Confidence</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

How confident are you that you can…

- Complete your activity using proper technique %
- Follow directions to complete the activity %
- Perform all of the movements required for your activity %
- Exercise when you feel discomfort from the activity %
- Be active when you lack energy %
- Include activity in your daily routine %
- Consistently be active every day of the week %
- Be active when you don’t feel well %
- Arrange your schedule to include regular activity %

Appendix O: Life Options’ Chronic Kidney Disease (CKD) Self-Management Survey

Participant ID: _________  Date: __________

Time: ☐ Screening Clinic  ☐ Discharge

Life Options’ CKD Self-management Survey  Developed by the Medical Education Institute, Inc.

Self-management of Activities Survey
About Life Options

As you may know, the Life Options Rehabilitation Program is dedicated to helping people live long and live well with kidney disease.


To better serve patients with kidney disease, the Life Options Rehabilitation Program has recently done studies to collect patients’ opinions and input about their experience with kidney disease, its treatments, and its effects or consequences. Life Options wants to know—from patients themselves—what they think, believe, and experience as they adapt to having kidney disease. Results from this work will be used to develop new materials designed to help patients achieve their goals, to reach their fullest potential, and to realize the full range of “life options” which are truly available to them.

For more information, contact the Life Options Rehabilitation Resource Center (RRC) at (800) 468-7777, visit the website at www.lifeoptions.org, or e-mail lifeoptions@MEIresearch.org. The Life Options Rehabilitation Program is administered by Medical Education Institute, Inc. of Madison, Wisconsin.
The questions in this part of the survey ask about things that you have done about your **KIDNEY PROBLEM AND TREATMENT**. Please answer the questions based on your own experience.

### During the PAST 6 MONTHS, how often have you **kept track of …**

<table>
<thead>
<tr>
<th></th>
<th>Never</th>
<th>A few times</th>
<th>A lot of the time</th>
<th>All the time</th>
<th>Does not apply</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Blood glucose (sugar) levels?</td>
<td>▼</td>
<td>▼</td>
<td>▼</td>
<td>▼</td>
<td>▼</td>
</tr>
<tr>
<td>2. Appointments with your doctor?</td>
<td>▼</td>
<td>▼</td>
<td>▼</td>
<td>▼</td>
<td>▼</td>
</tr>
<tr>
<td>3. Blood pressure?</td>
<td>▼</td>
<td>▼</td>
<td>▼</td>
<td>▼</td>
<td>▼</td>
</tr>
<tr>
<td>4. Thoughts and feelings about your health?</td>
<td>▼</td>
<td>▼</td>
<td>▼</td>
<td>▼</td>
<td>▼</td>
</tr>
<tr>
<td>5. Lab results related to how your kidneys are working?</td>
<td>▼</td>
<td>▼</td>
<td>▼</td>
<td>▼</td>
<td>▼</td>
</tr>
<tr>
<td>6. Symptoms of health conditions?</td>
<td>▼</td>
<td>▼</td>
<td>▼</td>
<td>▼</td>
<td>▼</td>
</tr>
<tr>
<td>7. Side effects of treatments?</td>
<td>▼</td>
<td>▼</td>
<td>▼</td>
<td>▼</td>
<td>▼</td>
</tr>
</tbody>
</table>

### During the PAST 6 MONTHS, how often have your symptoms influenced you to change your behavior by…

<table>
<thead>
<tr>
<th></th>
<th>Never</th>
<th>A few times</th>
<th>A lot of the time</th>
<th>All the time</th>
</tr>
</thead>
<tbody>
<tr>
<td>8. Rearranging your daily schedule?</td>
<td>▼</td>
<td>▼</td>
<td>▼</td>
<td>▼</td>
</tr>
<tr>
<td>9. Increasing or decreasing your physical activities?</td>
<td>▼</td>
<td>▼</td>
<td>▼</td>
<td>▼</td>
</tr>
<tr>
<td>10. Adjusting your food intake or food choices?</td>
<td>▼</td>
<td>▼</td>
<td>▼</td>
<td>▼</td>
</tr>
<tr>
<td>How often have you done the following health-related activities in the PAST 6 MONTHS…</td>
<td>Never</td>
<td>A few times</td>
<td>A lot of the time</td>
<td>All the time</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>11. Arranged your schedule to have enough time to rest or sleep?</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>12. Chosen healthier foods to eat?</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>13. Allowed time in your day for an enjoyable activity?</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>14. Taken time to unwind and feel better?</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>15. Exercised or stretched for 20 minutes or more?</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>16. Avoided talking with people who had negative attitudes about kidney disease and treatment?</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>17. Take medications as prescribed by your doctor?</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>During the PAST 6 MONTHS, how often have you talked with your doctor about the following…</th>
<th>Never</th>
<th>A few times</th>
<th>A lot of the time</th>
<th>All the time</th>
</tr>
</thead>
<tbody>
<tr>
<td>18. A treatment or medication that might be useful for you?</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>19. A medication that was not working the way you thought it should?</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>20. An adjustment you made on your own with your medication?</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
</tbody>
</table>
During the PAST 6 MONTHS, how often have you looked for information about kidney problems or treatments by … | Never | A few times | A lot of the time | All the time |
--- | --- | --- | ---
21. Talking with friends and/or family? | ▼ | ▼ | ▼ | ▼ |
22. Talking with your pharmacist? | ▼ | ▼ | ▼ | ▼ |
23. Talking with your doctor? | ▼ | ▼ | ▼ | ▼ |
24. Asking your doctor for more information? | ▼ | ▼ | ▼ | ▼ |
25. Asking for copies of lab value results? | ▼ | ▼ | ▼ | ▼ |
26. Asking questions about something you read related to disease, health and/or treatment? | ▼ | ▼ | ▼ | ▼ |
27. Reading books, magazines, or internet web-sites for information about health, disease, medications, or other treatments? | ▼ | ▼ | ▼ | ▼ |
28. Attending an educational class? | ▼ | ▼ | ▼ | ▼ |
29. Searching for a way to treat a problem, symptom, or side-effect? | ▼ | ▼ | ▼ | ▼ |
30. Going to another doctor for a second opinion? | ▼ | ▼ | ▼ | ▼ |
31. Writing questions down before seeing the doctor? | ▼ | ▼ | ▼ | ▼ |
<table>
<thead>
<tr>
<th>During the PAST 6 MONTHS, how often have you asked your doctor…</th>
<th>Never</th>
<th>A few times</th>
<th>A lot of the time</th>
<th>All the time</th>
<th>Does not apply</th>
</tr>
</thead>
<tbody>
<tr>
<td>32. To explain the medical terms in words you could understand?</td>
<td>□₁</td>
<td>□₂</td>
<td>□₃</td>
<td>□₄</td>
<td>□₅</td>
</tr>
<tr>
<td>33. For a change in your treatment?</td>
<td>□₁</td>
<td>□₂</td>
<td>□₃</td>
<td>□₄</td>
<td>□₅</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>During the PAST 6 MONTHS, how often have you spoken up to your doctor because you…</th>
<th>Never</th>
<th>A few times</th>
<th>A lot of the time</th>
<th>All the time</th>
<th>Does not apply</th>
</tr>
</thead>
<tbody>
<tr>
<td>34. Thought the doctor was doing something wrong?</td>
<td>□₁</td>
<td>□₂</td>
<td>□₃</td>
<td>□₄</td>
<td>□₅</td>
</tr>
<tr>
<td>35. Believed you were given the wrong treatment?</td>
<td>□₁</td>
<td>□₂</td>
<td>□₃</td>
<td>□₄</td>
<td>□₅</td>
</tr>
<tr>
<td>36. Wanted to get better care?</td>
<td>□₁</td>
<td>□₂</td>
<td>□₃</td>
<td>□₄</td>
<td>□₅</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Have you ever…</th>
<th>Never</th>
<th>A few times</th>
<th>A lot of the time</th>
<th>All the time</th>
</tr>
</thead>
<tbody>
<tr>
<td>37. Reported concerns to a higher authority?</td>
<td>□₁</td>
<td>□₂</td>
<td>□₃</td>
<td>□₄</td>
</tr>
<tr>
<td>38. Changed doctors because things were not being done the way you thought they should be?</td>
<td>□₁</td>
<td>□₂</td>
<td>□₃</td>
<td>□₄</td>
</tr>
<tr>
<td>39. Contacted provincial or federal representatives about health-care provision or coverage?</td>
<td>□₁</td>
<td>□₂</td>
<td>□₃</td>
<td>□₄</td>
</tr>
<tr>
<td>In the PAST 6 MONTHS, how often have you…</td>
<td>Never</td>
<td>A few times</td>
<td>A lot of the time</td>
<td>All the time</td>
</tr>
<tr>
<td>--------------------------------------</td>
<td>-------</td>
<td>-------------</td>
<td>-----------------</td>
<td>-------------</td>
</tr>
<tr>
<td>40. Taken a medication in different ways than it was prescribed?</td>
<td>▼</td>
<td>▼</td>
<td>▼</td>
<td>▼</td>
</tr>
<tr>
<td>41. Not taken a prescribed medication?</td>
<td>▼</td>
<td>▼</td>
<td>▼</td>
<td>▼</td>
</tr>
<tr>
<td>42. Used prescriptions from friends or family members, without the knowledge of your doctor or other healthcare providers?</td>
<td>▼</td>
<td>▼</td>
<td>▼</td>
<td>▼</td>
</tr>
<tr>
<td>43. Taken herbs, non-prescribed vitamins, or other natural remedies?</td>
<td>▼</td>
<td>▼</td>
<td>▼</td>
<td>▼</td>
</tr>
<tr>
<td>44. Used additional treatments other than what your doctor suggested?</td>
<td>▼</td>
<td>▼</td>
<td>▼</td>
<td>▼</td>
</tr>
</tbody>
</table>
The following statements are about talking with your doctor. As you read each statement think about how **confident you are in your ability** to do each. Answer by checking a box where 1 means “not at all” confident and 5 means “very” confident.

<table>
<thead>
<tr>
<th>How confident are you in your ability to:</th>
<th>Not at all 1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>Very 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>45. Know what questions to ask a doctor?</td>
<td>[ ] 1</td>
<td>[ ] 2</td>
<td>[ ] 3</td>
<td>[ ] 4</td>
<td>[ ] 5</td>
</tr>
<tr>
<td>46. Get a doctor to answer all of your questions?</td>
<td>[ ] 1</td>
<td>[ ] 2</td>
<td>[ ] 3</td>
<td>[ ] 4</td>
<td>[ ] 5</td>
</tr>
<tr>
<td>47. Make the most of your visit with a doctor?</td>
<td>[ ] 1</td>
<td>[ ] 2</td>
<td>[ ] 3</td>
<td>[ ] 4</td>
<td>[ ] 5</td>
</tr>
<tr>
<td>48. Get a doctor to take your chief health concern seriously?</td>
<td>[ ] 1</td>
<td>[ ] 2</td>
<td>[ ] 3</td>
<td>[ ] 4</td>
<td>[ ] 5</td>
</tr>
<tr>
<td>49. Get a doctor to do something about your chief health concern?</td>
<td>[ ] 1</td>
<td>[ ] 2</td>
<td>[ ] 3</td>
<td>[ ] 4</td>
<td>[ ] 5</td>
</tr>
</tbody>
</table>
These statements are about health activities. As you read each statement think about how important it is to you and how confident you are in your ability to do each.

<table>
<thead>
<tr>
<th>Activities:</th>
<th>Not at all 1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>Very 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>50. Make decisions about what is best for your health</td>
<td>▼</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>How important?</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>How confident?</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>51. Search for ways to treat a symptom or side effect</td>
<td>▼</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>How important?</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>How confident?</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>52. Make decisions about your problems</td>
<td>▼</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>How important?</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>How confident?</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>53. Learn what kidneys do</td>
<td>▼</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>How important?</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>How confident?</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>54. Learn about kidney treatments</td>
<td>▼</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>How important?</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>How confident?</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>55. Manage your kidney problems</td>
<td>▼</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>How important?</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>How confident?</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>56. Adjust your activities to improve your health</td>
<td>▼</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>How important?</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>How confident?</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Activities:</td>
<td>Not at all 1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>Very 5</td>
</tr>
<tr>
<td>-------------------------------------</td>
<td>--------------</td>
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<td></td>
<td>▼</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td><strong>57. Adjust your food intake</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>to improve your health</td>
<td>How important?</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>How confident?</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td><strong>58. Enjoy life's pleasures</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>even when ill</td>
<td>How important?</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>How confident?</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td><strong>59. Do special things for</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>your-self to make life better</td>
<td>How important?</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>How confident?</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>

**THANK YOU FOR COMPLETING THIS QUESTIONNAIRE!**
Appendix P: 30-Second Chair Stand Test

The 30-Second Chair Stand Test

Purpose: To test leg strength and endurance

Equipment:
- A chair with a straight back without arm rests (seat 17" high)
- A stopwatch

Instructions to the patient:
1. Sit in the middle of the chair.
2. Place your hands on the opposite shoulder crossed at the wrists.
3. Keep your feet flat on the floor.
4. Keep your back straight and keep your arms against your chest.
5. On “Go,” rise to a full standing position and then sit back down again.
6. Repeat this for 30 seconds.

On “Go,” begin timing.
If the patient must use his/her arms to stand, stop the test. Record “0” for the number and score.
Count the number of times the patient comes to a full standing position in 30 seconds.
If the patient is over halfway to a standing position when 30 seconds have elapsed, count it as a stand.
Record the number of times the patient stands in 30 seconds.

Number: __________ Score __________ See next page.

A below average score indicates a high risk for falls.

Notes:

For relevant articles, go to: www.cdc.gov/injury/STEADI

Appendix Q: Berg Balance Scale

Berg Balance Scale

SITTING TO STANDING
INSTRUCTIONS: Please stand up. Try not to use your hand for support.
(  ) 4 able to stand without using hands and stabilize independently
(  ) 3 able to stand independently using hands
(  ) 2 able to stand using hands after several tries
(  ) 1 needs minimal aid to stand or stabilize
(  ) 0 needs moderate or maximal assist to stand

STANDING UNSUPPORTED
INSTRUCTIONS: Please stand for two minutes without holding on.
(  ) 4 able to stand safely for 2 minutes
(  ) 3 able to stand 2 minutes with supervision
(  ) 2 able to stand 30 seconds unsupported
(  ) 1 needs several tries to stand 30 seconds unsupported
(  ) 0 unable to stand 30 seconds unsupported

If a subject is able to stand 2 minutes unsupported, score full points for sitting unsupported. Proceed to item #4.

SITTING WITH BACK UNSUPPORTED BUT FEET SUPPORTED ON FLOOR OR ON A STOOL
INSTRUCTIONS: Please sit with arms folded for 2 minutes.
(  ) 4 able to sit safely and securely for 2 minutes
(  ) 3 able to sit 2 minutes under supervision
(  ) 2 able to sit 30 seconds
(  ) 1 able to sit 10 seconds
(  ) 0 unable to sit without support 10 seconds

STANDING TO SITTING
INSTRUCTIONS: Please sit down.
(  ) 4 sits safely with minimal use of hands
(  ) 3 controls descent by using hands
(  ) 2 uses back of legs against chair to control descent
(  ) 1 sits independently but has uncontrolled descent
(  ) 0 needs assist to sit

TRANSFERS
INSTRUCTIONS: Arrange chair(s) for pivot transfer. Ask subject to transfer one way toward a seat with armrests and one way toward a seat without armrests. You may use two chairs (one with and one without armrests) or a bed and a chair.
(  ) 4 able to transfer safely with minor use of hands
(  ) 3 able to transfer safely definite need of hands
(  ) 2 able to transfer with verbal cuing and/or supervision
(  ) 1 needs one person to assist
(  ) 0 needs two people to assist or supervise to be safe

STANDING UNSUPPORTED WITH EYES CLOSED
INSTRUCTIONS: Please close your eyes and stand still for 10 seconds.
(  ) 4 able to stand 10 seconds safely
(  ) 3 able to stand 10 seconds with supervision
(  ) 2 able to stand 3 seconds
(  ) 1 unable to keep eyes closed 3 seconds but stays safely
(  ) 0 needs help to keep from falling

STANDING UNSUPPORTED WITH FEET TOGETHER
INSTRUCTIONS: Place your feet together and stand without holding on.
(  ) 4 able to place feet together independently and stand 1 minute safely
(  ) 3 able to place feet together independently and stand 1 minute with supervision
(  ) 2 able to place feet together independently but unable to hold for 30 seconds
(  ) 1 needs help to attain position but able to stand 15 seconds feet together
(  ) 0 needs help to attain position and unable to hold for 15 seconds
Berg Balance Scale continued…

REACHING FORWARD WITH OUTSTRETCHED ARM WHILE STANDING
INSTRUCTIONS: Lift arm to 90 degrees. Stretch out your fingers and reach forward as far as you can. (Examiner places a ruler at the end of fingertips when arm is at 90 degrees. Fingers should not touch the ruler while reaching forward. The recorded measure is the distance forward that the fingers reach while the subject is in the most forward lean position. When possible, ask subject to use both arms when reaching to avoid rotation of the trunk.)
(    ) 4 can reach forward confidently 25 cm (10 inches)
(    ) 3 can reach forward 12 cm (5 inches)
(    ) 2 can reach forward 5 cm (2 inches)
(    ) 1 reaches forward but needs supervision
(    ) 0 loses balance while trying/requires external support

PICK UP OBJECT FROM THE FLOOR FROM A STANDING POSITION
INSTRUCTIONS: Pick up the shoe/slipper, which is in front of your feet.
(    ) 4 able to pick up slipper safely and easily
(    ) 3 able to pick up slipper but needs supervision
(    ) 2 unable to pick up but reaches 2-5 cm (1-2 inches) from slipper and keeps balance independently
(    ) 1 unable to pick up and needs supervision while trying
(    ) 0 unable to try/needs assist to keep from losing balance or falling

TURNING TO LOOK BEHIND OVER LEFT AND RIGHT SHOULDERS WHILE STANDING
INSTRUCTIONS: Turn to look directly behind you over the left shoulder. Repeat to the right. (Examiner may pick an object to look at directly behind the subject to encourage a better twist turn.)
(    ) 4 looks behind from both sides and weight shifts well
(    ) 3 looks behind one side only other side shows less weight shift
(    ) 2 turns sideways only but maintains balance
(    ) 1 needs supervision when turning
(    ) 0 needs assist to keep from losing balance or falling

TURN 360 DEGREES
INSTRUCTIONS: Turn completely around in a full circle. Pause. Then turn a full circle in the other direction.
(    ) 4 able to turn 360 degrees safely in 4 seconds or less
(    ) 3 able to turn 360 degrees safely one side only 4 seconds or less
(    ) 2 able to turn 360 degrees safely but slowly
(    ) 1 needs close supervision or verbal cuing
(    ) 0 needs assistance while turning

PLACE ALTERNATE FOOT ON STEP OR STOOL WHILE STANDING UNSUPPORTED
INSTRUCTIONS: Place each foot alternately on the step/stool. Continue until each foot has touched the step/stool four times.
(    ) 4 able to stand independently and safely and complete 8 steps in 20 seconds
(    ) 3 able to stand independently and complete 8 steps in > 20 seconds
(    ) 2 able to complete 4 steps without aid with supervision
(    ) 1 able to complete > 2 steps needs minimal assist
(    ) 0 needs assistance to keep from falling/unable to try

STANDING UNSUPPORTED ONE FOOT IN FRONT
INSTRUCTIONS: (DEMONSTRATE TO SUBJECT) Place one foot directly in front of the other. If you feel that you cannot place your foot directly in front, try to step far enough ahead that the heel of your forward foot is ahead of the toes of the other foot. (To score 3 points, the length of the step should exceed the length of the other foot and the width of the stance should approximate the subject’s normal stride width.)
(    ) 4 able to place foot tandem independently and hold 30 seconds
(    ) 3 able to place foot ahead independently and hold 30 seconds
(    ) 2 able to take small step independently and hold 30 seconds
(    ) 1 needs help to step but can hold 15 seconds
(    ) 0 loses balance while stepping or standing

STANDING ON ONE LEG
INSTRUCTIONS: Stand on one leg as long as you can without holding on.
(    ) 4 able to lift leg independently and hold > 10 seconds
(    ) 3 able to lift leg independently and hold 5-10 seconds
(    ) 2 able to lift leg independently and hold ≥ 3 seconds
(    ) 1 tries to lift leg unable to hold 3 seconds but remains standing independently.
(    ) 0 unable to try of needs assist to prevent fall

(    ) TOTAL SCORE (Maximum = 56)