THE EFFECTS OF AN INTRA-DIALYTIC EXERCISE PROGRAM ON SELF-EFFICACY AND PHYSICAL ACTIVITY: A PILOT STUDY

by

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A thesis submitted to the School of Rehabilitation Therapy

In conformity with the requirements for

the degree of Master of Science

Queen's University

Kingston, Ontario, Canada

(July, 2010)

Abstract

Background: Levels of physical activity are significantly lower among individuals with end-stage renal disease (ESRD) compared to their healthy sedentary counterparts. Low levels of self-efficacy (SE) with respect to exercise may contribute to a sedentary lifestyle in the ESRD population. Therefore, in a pilot investigation we examined the effects of an 8-week intra-dialytic (ID) exercise program on SE and physical activity (PA) in hemodialysis (HD) patients and determined the appropriateness and sensitivity of the selected outcome measures and proposed intervention.

Methods: HD patients were randomized into an Exercise group (EX, n=4) or a Control group (CON, n=4). The EX group cycled for approximately 60 min during HD, thrice weekly for 8 weeks. The CON group continued with their usual activity. At 8 weeks, participants in both groups had the option to participate in the exercise program. Physical Activity was determined using the Human Activity Profile (Maximal Activity Score, MAS; Adjusted Activity Score, AAS) and SE was evaluated using the Chronic Disease Self-Efficacy Scale (CDSES) and Exercise Self-Efficacy Scale (ESES). Measures were obtained at pre, post and 8 weeks following the intervention.

Results: No significant changes in PA or SE occurred between or within groups at any time point. Limited statistical power due to the small sample size and a ceiling effect due to initial high-function levels of the participants may have contributed to the lack of significant changes. MAS and AAS were generally lower in the CON group. Age was significantly associated with the AAS, MAS, and the Perform Social/Recreational Activities sub-scale of the CDSES. Serum albumin was significantly related to the AAS and the Exercise Regularly and Do Chores sub-scales of the CDSES.

Conclusions: Age and albumin should be taken into account when assessing physical activity in HD patients. Recruitment of additional participants is required to more clearly define the role of intra-dialytic exercise in enhancing exercise self-efficacy and physical activity in HD patients.

Acknowledgements

I have been fortunate to have the help and support of many people, without whom I would not have been able to accomplish what I have today.

First, and foremost, I would like to thank my friends and family for their unwavering love and support. Mom and Dad, you are my pillars of strength. Your steadfast belief in my abilities and constant encouragement have been, and continue to be, the cornerstone of my confidence and determination to overcome obstacles and pursue my goals. Andrew, I cannot express how grateful I am for your friendship. You have always been a source of immense support, encouragement, love, and laughter. Thank you.

To my supervisor Dr. Cheryl King-VanVlack, thank you for all of your support and guidance. Your demand for excellence constantly challenged me to work at a level that allowed me to reach my potential. You have taught me to think more rigorously and critically and have helped me to become a more incisive writer. Further, I would like to acknowledge the members of my advisory committee, Dr. Edwin Toffelmire and Dr. Trisha Parsons. In addition to your constant support and optimism, I cannot express how appreciative I am for your invaluable input and contributions toward my project; you were instrumental in the successful completion of my thesis. I would also like to thank you for providing an environment that fostered collaboration, support and friendship. Additionally, I would like to thank Shannon Kack for her willingness to help cover exercise sessions.

Lastly, I would like to extend my gratitude to the participants in this study for their outstanding commitment to the project and the gracious and friendly manner with which they treated me. I am also very appreciative of their willingness to share their experiences; it helped me gain a more comprehensive understanding of chronic kidney disease. To the nursing staff, thank you for making me feel so welcome in the dialysis unit; your support and collaboration truly helped to facilitate this study.

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LIST OF ABBREVIATIONS

AAS- Adjusted Activity Score of the HAP
ANCOVA- Analysis of Covariance
ANOVA- Analysis of Variance
CDSES- Chronic Disease Self-Efficacy Scale
CHOICE- Choices for Healthy Outcomes in Caring for ESRD
CI- Confidence Interval
DMMS- Dialysis Morbidity and Mortality Study
EF- Ejection Fraction
ESA- Erytropoeisis Stimulating Agents
ESES- Exercise Self-Efficacy Scale
ESRD- End-Stage Renal Disease
FUP- Follow-Up; 8-weeks post-intervention
HAP- Human Activity Profile
HD- Hemodialysis
HR- Hazard Ratio
HRV- Heart Rate Variability
KDOQI- Kidney Disease Outcomes Quality Initiative
Kt/V-Dialysis Adequacy
LEDV- Left Ventricular End Diastolic Volume
LV- Left Ventricular
MAS- Maximal Activity Score of the HAP
MET- Metabolic Equivalent
NHANES- National Health and Nutrition Examination Survey
OR- Odds Ratio
PF- Physical Functioning Scale of the SF-36
PAR- Stanford 7-day Physical Activity Recall Questionnaire
PASE- Physical Activity Scale for the Elderly
PCR- Protein Catabolic Rate
PCS- Physical Component Summary score of the SF-36
POST- Post-Intervention; end of the 8-week intervention
PRE- Pre-Intervention; before the start of the 8-week intervention
RR- Relative Risk
R-R interval- Longest interval between two successive R waves on and ECG recording
RMR-Resting Metabolic Rate
SCI- Spinal Cord Injury
SF-36- Short Form 36-Item Questionnaire
SVI- Stroke Volume Index
VO_{2peak}- Peak Oxygen Uptake

Chapter 1

Introduction

As of 2008, the number of Canadians living with end-stage renal disease (ESRD) and receiving renal replacement therapy was 36,638; an increase of 57% from 1999 (Canadian Institute for Health Information, 2010). Of great concern is the prevailing trend for increased incidence of ESRD. In 1999, the number of patients newly diagnosed with ESRD was 4,551; by 2008 that number had increased by 19% to 5,431 individuals (Canadian Institute for Health Information, 2010). This rising incidence and prevalence has serious implications due to the significant health and financial consequences of ESRD. The high-cost treatment options for ESRD place a large economic burden on the Canadian health care system (Zelmer, 2007). Further, and of greater consequence, are the poor outcomes associated with ESRD. The 5-year survival rate for those on dialysis aged 45-64 is approximately 50% (Canadian Institute for Health Information, 2008). Additionally, diabetes, which continues to be the predominant cause of renal failure in Canada, dramatically reduces the survival rate, increasing the risk of mortality by 59% (Canadian Institute for Health Information, 2010).

End-stage renal disease is an irreversible deterioration in renal function where less than 10% renal function remains (McCance & Huether, 2001). Consequently, there is a progressive accumulation of compounds throughout the body, commonly referred to as uremic toxins, which leads to the clinical syndrome of uremia (McCance & Huether, 2001). The uremic syndrome is characterized by a myriad of symptoms and accompanying endocrine and metabolic abnormalities which occur largely as a result of uremic neuropathies and myopathies (Chikotas, Gunderman, & Oman, 2006). Symptoms manifest throughout all organ systems of the body and notably include anemia, cardiac dysfunction, impaired cardiac autonomic control, impaired skeletal muscle oxidative metabolism, muscle atrophy, and vascular abnormalities (Kouidi, 2001). As a result, individuals with ESRD suffer from substantive functional limitations including low cardiorespiratory function, skeletal muscle weakness and fatigue, and general feelings of malaise; effectively reducing their exercise tolerance, functional capacity, and quality of life (Cheema & Singh, 2005; Chikotas, Gunderman, & Oman, 2006; Kouidi, 2001; Painter, 2005). The aerobic capacity and muscle strength of uremic individuals is reported to be approximately 50% of age-expected levels (Kouidi, 2001; Painter, 2005), limiting their ability to perform physical activity and precipitating a downward spiral of deconditioning toward reduced physical capacity and disability (Painter, 2005).

It has been said that “if the benefits of exercise could be packaged into a pill it would be the single, most widely prescribed and beneficial medicine..”-Dr. Robert N Butler, Former Director, National Institute of Ageing (Cheema, 2008). Over three decades of research have revealed the myriad of health and clinical benefits of prescribed exercise in individuals with ESRD (Cheema, 2008). Exercise has the capacity to attenuate many of the consequences of the uremic syndrome by improving skeletal muscle structure and function, cardiac performance, autonomic functioning, mood, and lipid profile (Cheema & Singh, 2005; Chikotas et al., 2006; Kouidi, 2001; Painter, 2005). Functionally, these changes manifest as increased muscle strength and endurance, increased exercise tolerance, improved physical function, and enhanced quality of life. Regular physical activity also has the ability to mitigate the risk of early mortality in this population by modifying risk factors predictive of outcomes, particularly those associated with cardiovascular disease; the number one cause of mortality in the ESRD population (Johansen, 2007).

Unfortunately, the majority of individuals with ESRD lead a sedentary lifestyle, participating in significantly less physical activity than sedentary healthy age-matched individuals

(Johansen et al., 2000; Longenecker et al., 2002). Only 10% of the ESRD population participate in recommended levels of physical activity, while the majority (51%) report performing no physical activity beyond basic activities of daily living (Painter, Carlson, Carey, Paul, & Myll, 2000b). In order to optimize physical function in the ESRD population, it is necessary to promote physical activity as part of the management of the condition.

There are numerous variables which influence physical activity; however, self-efficacy, one's perception of personal capabilities, has consistently been identified as a significant predictor of physical activity behaviour in both healthy and symptomatic populations (Carlson et al., 2001; Culos-Reed & Brawley, 2000; Jeng et al., 2002; Kaewthummanukul & Brown, 2006; Kaplan, Ries, Prewitt, & Eakin, 1994; McAuley, 1993; McAuley et al., 2007; McAuley, Courneya, Rudolph, & Lox, 1994; McAuley, Jerome, Elavsky, Marquez, & Ramsey, 2003a; Millen & Bray, 2008; Oka, Gortner, Stotts, & Haskell, 1996; Rejeski, Martin Jr., Ettinger, & Morgan, 1998; Rovniak, Anderson, Winett, & Stephens, 2002; Sallis et al., 1986; Sallis, Hovell, & Hofstetter, 1992; Sharma, Sargent, & Stacy, 2005; Strachan, Woodgate, Brawley, & Tse, 2005). The utility of self-efficacy enhancing strategies in facilitating changes in exercise behaviour has been demonstrated in many chronic disease populations (Barlow, Turner, & Wright, 2000; Carlson et al., 2001; Lox & Freehill, 1999). In the ESRD population, the social cognitive theory has been successfully applied to self-management behaviours including self-care, medication/treatment adherence, and communication and partnership with members of the healthcare team (Curtin et al., 2008; Tsay, 2003). However, there is an apparent lack of research investigating the role of self-efficacy in physical activity and exercise in this population.

Preliminary investigations of 13 individuals with ESRD on hemodialysis indicated that levels of daily physical activity could be strongly predicted by one's perceived ability to participate in exercise and social and recreational activities (r^2=0.92) (personal communication-

Dr. Cheryl King-VanVlack, January 26, 2009). Self-efficacy can be enhanced through enactive mastery experiences, successfully completing a given activity, vicarious experience, seeing others who are perceived to be similar to oneself manage task demands successfully, verbal persuasion, and physiological or affective states (Bandura, 1997).

The current investigation was a pilot study to determine the effects of a low-intensity intra-dialytic exercise program on self-efficacy and physical activity in hemodialysis patients. Pre-existing self-report measures of self-efficacy and physical activity were chosen to determine if changes in these outcomes would accompany participation in an exercise program, thus allowing assessment of both the appropriateness and sensitivity of these measures and the intervention.

Chapter 2

Literature Review

2.1 Physical Activity and Physical Function in ESRD

2.1.1 Physical Activity

Physical activity is defined as "any bodily movement produced by skeletal muscles that results in energy expenditure above basal requirements" (Caspersen, Powell, & Christenson, 1985). Currently, no physical activity guidelines exist specifically for the ESRD population. However, the numerous national guidelines published for the general population are applicable to the ESRD population, especially considering they are designed to positively affect medical concerns that are prevalent in this population including cardiovascular disease, hypertension, and physical function (Painter et al., 2000b; Painter, 2005). In fact, recommendations from current national guidelines have been incorporated into the Kidney Disease Outcome Quality Initiative (KDOQI) clinical practice guidelines for managing cardiovascular risk factors (National Kidney Foundation, 2005) and *Exercise:A Guide for People on Dialysis* (Painter, 2000), a reference guide developed by the Life Options Advisory Council. To obtain improvements in health and well-being, the Surgeon General's *Physical Activity and Health* report recommends 30 minutes of moderate physical activity most, if not all, days of the week (150 kcal/day or 1000 kcal/week) (Office of the US Surgeon General, 1999). In addition to cardiovascular exercise, the American College of Sports Medicine and the American Heart Association recommend performing resistance training twice per week to sustain or improve muscular strength and preserve the ability to continue independent living (Haskell et al., 2007).

The majority of individuals with ESRD lead sedentary lifestyles (Allen & Gappmaier, 2001; Johansen et al., 2000; Longenecker et al., 2002; Majchrzak et al., 2005; Stack & Murthy, 2008; Zamojska, Szklarek, Niewodniczy, & Nowicki, 2006); most do not participate in any physical activity beyond basic activities of daily living (Painter et al., 2000b). Data from the Dialysis Morbidity and Mortality Study (DMMS) Wave 2 showed that in 2,264 incident (newly diagnosed) ESRD patients, 56% reported exercising one time per week or less (O'Hare, Tawney, Bacchetti, & Johansen, 2003; Stack & Murthy, 2008). Forty-four percent did report exercising at least 2-3 times per week, but 75% of the population reported severe limitation in vigorous activity (i.e. running/strenuous sport) and 42% reported severe limitation in moderate physical activity (i.e. moving a table/pushing a vacuum), suggesting that the activities they were performing were likely low-intensity. Similarly, Allen and Gappmaier (2001) found that in 135 hemodialysis (HD) patients, 40% performed no weekly physical activity and 60% reported being physically active at least once per week. However, the majority (74%) performed low-intensity, recreational activities (2.0-4.9 kcal/min) that did not elicit sufficient weekly energy expenditures to obtain health benefits (i.e. <1000 kcal/week). Only 10% of the participants engaged in adequate levels of physical activity to improve health and well-being (i.e. >1000 kcal/week). In the Renal Exercise Demonstration Project, 51% of 268 HD patients reported no physical activity greater than activities of daily living and only 12% reported meeting the activity guidelines recommended by the Surgeon General (Painter et al., 2000b). However, following a 16-week exercise intervention, 8 weeks of independent home exercise, followed by 8 weeks of in-centre intra-dialytic cycling, 60% of the participants successfully incorporated change into their habitual physical activity behaviour (Painter et al., 2000b). The percentage of participants performing the recommended levels of physical activity increased to 45% and the proportion reporting participation in only activities of daily living decreased to 6.4%. Further, the group of lower functioning participants, who were identified based on baseline levels of self-reported physical function, showed significant increases in physical activity levels following the intervention (Painter, Carlson, Carey, Paul, & Myll, 2000a). The proportion of participants in the group who indicated performing only activities of daily living decreased 60%, from 69.4% at baseline to 9.3% following the intervention. At the end of the intervention, 38.9% reported engaging in the recommended levels of cardiovascular exercise (Painter et al., 2000a), similar to the participation rates (37%) in the general U.S. population (Office of the US Surgeon General, 1999). These results challenge the widely held misconception that extremely deconditioned individuals are unable to increase physical activity levels (Painter et al., 2000a).

Not only are individuals with ESRD typically inactive, but their levels of activity are significantly less than those reported in the general population. Using self-report data from two national studies, the Choices for Healthy Outcomes in Caring for ESRD (CHOICE) Study and the Third National Health and Nutrition Examination Survey (NHANES III), Longenecker *et al.* (2002) compared the prevalence of atherosclerotic cardiovascular disease risk factors in incident ESRD patients (n=1,041) and the general population (n=19,753). When the NHANES estimates were adjusted to the age, gender, race, and atherosclerotic cardiovascular disease distribution of the CHOICE cohort, the prevalence of physical inactivity was significantly greater in the ESRD population than the general population. Compared with 31% in the general population, only 14% of incident dialysis patients reported participating in physical activity to perspiration three or more times a week (≥5.0 METS, ≥ 3 times/week).

Robust differences in daily physical activity levels between ESRD patients and healthy sedentary individuals have also been shown using objective measures of physical activity including accelerometry (Johansen et al., 2000; Majchrzak et al., 2005) and pedometry (Zamojska et al., 2006). Accelerometry data, showed that HD patients are approximately 35% less active than healthy sedentary controls (104,728±9,631 vs. 161,255±6,792 arbitrary units/day, $p<0.001$) (Johansen et al., 2000). Similar levels of inactivity among HD patients (n=20) were reported by Majchrzak *et al.* (2005) who found the physical activity counts to be 168,744±95,168 on dialysis days and 128,279±74,009 on non-dialysis days. Further, when the accelerometry data (kcal/day) were converted to physical activity levels (PALs) (total energy expenditure divided by resting metabolic rate), values for the HD participants (1.2 and 1.3) (Majchrzak et al., 2005) were lower than those reported for healthy men and women (1.4-1.6) (Saris et al., 2003). Additionally, accelerometry data indicated that physical activity levels among HD patients (n=54) declined at a significant rate of 3.4% per month (-3,390±1,276 arbitrary units/month, $p=0.012$) (Johansen et al., 2003a). Although physical activity levels are expected to decline with time due to increasing age (r=-0.65, $p<0.0001$), the decrease in activity level is considerably more rapid for HD patients than for healthy sedentary individuals (Johansen et al., 2000). To demonstrate this point, Johansen *et al.*(2000) reported the estimated effect of age and dialysis status on the physical activity levels of a male HD patient compared with a healthy sedentary male control subject (matched for a BMI of 23 kg/m^2). The predicted level of activity at age 30 was 15% lower in the HD patient than the healthy sedentary control; the discrepancy further increased to 57% at age 70. This accelerated decrease in physical activity is particularly concerning given the already reduced levels of physical activity among the ESRD population. Further, Majchrzak *et al.* (2005) showed that diabetic HD patients were significantly less active than non-diabetic HD patients (82,397±48,166 vs. 152, 985±74,987 physical activity counts/day). This may have serious implications since diabetes continues to be the predominant cause of ESRD, accounting for 35% of incident patients in Canada (Canadian Institute for Health Information, 2010).

Physical activity patterns in the ESRD population assessed objectively by pedometry further substantiate the previous findings that HD patients are significantly less active than healthy individuals. Zamojska *et al.* (2006) found that, on average, HD patients (n=60) were taking less than half as many steps as age-matched healthy individuals (n=16) (6,896±2,357steps vs. 14,181± 5,383/48 hours, p<0.001).

In contrast, individuals with chronic kidney disease who meet the recommended guidelines of physical activity tend to greatly exceed them. In the Lipid Lowering and Onset of Renal Disease (LORD) trial, 50% of the 120 chronic kidney disease participants reported meeting the cut-off of 600 MET·min·week^{-1}, which was the criterion reflecting Australia's national activity guidelines of moderate activity 5 days per week (Fassett et al., 2009). A MET is a measure which represents the rate of energy expenditure of a given activity as a multiple of the resting metabolic rate (RMR), which is equivalent to 1 MET. The RMR is defined as 1 kcal·kg^{-1}·h^{-1} or 3.5 mL O_2· kg^{-1}·min^{-1} (Lagerros & Lagiou, 2007). The mean energy expenditure of those meeting the cut-off was 2,432±2,174 MET·min·week^{-1}, indicating that many of these individuals were performing high levels of activity. On the other hand, participants who failed to meet the cut-off typically engaged in levels of physical activity that were considerably lower than the national recommendations (i.e. 600 MET·min·week^{-1}) and significantly less than those meeting the guidelines (223±169 vs. 2,432±2,174 MET·min·week^{-1}). Similar activity patterns were reported by Brenner and Brohart (2008), who divided 19 HD patients into two groups based on weekly MET scores; top 50% or lower 50%. Those in the top 50% reported significantly greater mean weekly physical activity MET scores compared with those in the lower 50% (17.1±3.6 vs. 5.2±1.5 MET·week^{-1}, $p\leq0.05$). Further, participants in the high MET group were more likely than the lower MET group to participate in activities other than those of daily living such as hockey, skating, running, cycling, swimming, weight lifting, and conditioning exercises (Brenner & Brohart, 2008).

2.1.1.1 Methods of Assessment of Physical Activity

Physical activity is a difficult phenomenon to measure accurately and reliably because of its multidimensional nature (Lagerros & Lagiou, 2007). There are greater than 30 methods that can be employed to measure physical activity (LaPorte, Montoye, & Caspersen, 1985), each with their respective strengths and limitations (Lagerros & Lagiou, 2007; LaPorte et al., 1985; Valanou, Bamia, & Trichopoulou, 2006; Warms, 2006). The proliferation of measurement methods is testament to the fact that no single method is capable of providing a valid, reliable, and practical way of measuring physical activity while not altering normal physical activity patterns. In chronic disease populations, measuring physical activity becomes increasingly complex because of changes in how major muscles are used, changes in the energy cost of an activity, and changes in the types of activities that can be done (Warms, 2006). Further, many factors (i.e. medications, and neuropathies) affect the accuracy of heart rate monitoring as an indicator of activity level (Warms, 2006) and different physiological responses are often elicited for a specific intensity activity which affect the accuracy of perceived intensity levels (Lagerros & Lagiou, 2007).

Physical activity can be measured objectively or by self-report. Objective measures of physical activity that are considered to be the “gold standard” are doubly labeled water and direct and indirect calorimetry (Warms, 2006). However, the high cost and need for special equipment and highly trained personnel make these measures impractical for large scale studies (Lagerros & Lagiou, 2007; Valanou et al., 2006; Warms, 2006). Motion sensors, such as accelerometers and pedometers, appear to provide attractive alternatives (Valanou et al., 2006). Pedometers register movement in the vertical direction, counting the number of steps over a period of time (Valanou et al., 2006). Their main advantage is that pedometers are relatively inexpensive and are unobtrusive (Valanou et al., 2006; Warms, 2006). Limitations of pedometers are that they are unable to quantitate the frequency and intensity of movement and cannot store data; making it difficult to make inferences about activity patterns (Valanou et al., 2006; Warms, 2006). Additionally, the accuracy of pedometers has been questioned due to large measurement error reported when recording slow or fast walking speeds with earlier models (Tudor-Locke & Myers, 2001; Warms, 2006); however, newer pedometers have been shown to be very accurate (Schneider, Crouter, & Bassett, 2004). Pedometers are suggested to be a suitable method for measuring physical activity in sedentary populations since they provide a good indication of walking activity and are able to capture spontaneous physical activity; characteristic behaviours of sedentary individuals (Tudor-Locke & Myers, 2001; Tudor-Locke, Williams, Reis, & Pluto, 2002).

Accelerometers quantify body movement by registering electrical charges that are obtained from the distortion of piezoelectric ceramic sensors (Tudor-Locke & Myers, 2001); they can be uniaxial (measuring movements in the vertical plane only) or triaxial (measuring movement in 3 planes, omnidirectional) (Tudor-Locke & Myers, 2001). Compared with pedometers, which cannot quantitate frequency or intensity, accelerometers are able to provide data on the frequency, duration, and intensity of activity (Lagerros & Lagiou, 2007; Tudor-Locke & Myers, 2001; Valanou et al., 2006; Warms, 2006). Accelerometers are valid measures of physical activity when compared with calorimetric and doubly labeled water methods in free-living individuals (Westerterp, 1999) and are often used as a criterion measure when validating other measurement tools (Valanou et al., 2006). Further, tri-axial accelerometers have been reported to be the most sensitive device for measuring variability in activity levels in sedentary populations (Bouten, Westerterp, Verduin, & Janssen, 1994; Warms, 2006). Although accelerometers are less expensive than doubly labeled water and calorimetry, the expense still limits their use in large scale studies (Johansen et al., 2001b; Warms, 2006).

Self-report instruments are the most widely used form of physical activity measurement because they are practical, are of relatively low cost, tend to interfere minimally with habitual activity, and typically place little demand on participants (Valanou et al., 2006). Types of self-report measures include physical activity records (diaries and logs), recall questionnaires, quantitative history questionnaires, and global self report questionnaires (Valanou et al., 2006). The major limitation of self-report measures is that they rely on a participant's memory. Consequently, reliability and validity are compromised due to the inherent problems associated with recall, including social desirability bias (LaPorte et al., 1985; Valanou et al., 2006; Warms, 2006). Self-report questionnaires widely used to measure physical activity in the ESRD population include the Stanford 7-day Physical Activity Recall questionnaire (PAR), the Physical Activity Scale for the Elderly (PASE) and the Human Activity Profile (HAP): Maximal Activity Score (MAS) and Adjusted Activity Score (AAS) (Johansen et al., 2001b). Normative values for these measures indicate that dialysis patients typically report lower levels of physical activity than healthy individuals (PAR dialysis=33.3±2.3, healthy=38.4±5.8 $p<0.001$; PASE dialysis=90.3±76.8, healthy=102.9±64.9; HAP MAS dialysis=70.4±15.0, healthy=85.3±7.0, $p<0.001$; HAP AAS dialysis=55.4±21.5, healthy=83.2±7.8, $p<0.001$) (Johansen et al., 2001b). In a study of 39 HD patients, Johansen *et al.* (2001b) established that each of these questionnaires provided a reliable and valid method of measuring physical activity in HD patients. All questionnaires correlated at least moderately well with accelerometer measures of physical activity, correlation coefficients ranged from r=0.59 to 0.78. However, the MAS correlated best with physical activity measured by accelerometry (r=0.78, $p<0.0001$) and was the best predictor of physical activity, explaining 61% of the variability in physical activity ($r^2=0.61$). Therefore, Johansen *et al.* (2001b, p. 1124) determined that, "the HAP [was] the best single questionnaire substitute for quantitative measurement of physical activity in patients on hemodialysis."

2.1.2 Physical Function

Low levels of physical activity among individuals with ESRD are generally accompanied by low physical functioning (Johansen et al., 2003a; O'Hare et al., 2003; Painter et al., 2000a; Painter et al., 2000b). Physical functioning can be defined as "an individual's ability to perform activities required in their daily lives" (Painter, 2005). Factors which contribute to an individual's level of physical function include physical fitness (cardiorespiratory fitness, strength, and flexibility), sensory function, clinical condition, environmental factors, and behaviour factors (Painter, 2005). Low levels of physical functioning among HD patients have been shown by objective laboratory measures of exercise tolerance end-points (Moore et al., 1993b; Painter et al., 2002; Storer, Casaburi, Sawelson, & Kopple, 2005), physical performance-based measures (Johansen et al., 2000; Painter et al., 2000b), and self-report (Johansen et al., 2000; O'Hare et al., 2003; Painter et al., 2000b).

Values of peak oxygen uptake (VO_{2peak}) reported for HD patients show that they have considerably impaired aerobic capacities. Individuals on HD typically have VO_{2peak} values that are approximately 50-60% of age predicted norms for healthy sedentary individuals (Johansen et al., 2010). Peak oxygen uptake values in HD patients range from 14.8 (Moore et al., 1993b; Storer et al., 2005) to 26.3 $ml \cdot kg^{-1} \cdot min^{-1}$(Suh, Jung, Kim, Park, & Yang, 2002) while normative values for healthy individuals range from 35 to 45 $ml \cdot kg^{-1} \cdot min^{-1}$(Painter, 2005). Anemia is common in renal disease and likely contributes significantly to the reduced aerobic capacity in HD patients. When hemoglobin levels are corrected with erythropoiesis-stimulating agents (ESAs) in HD patients their exercise tolerance increases significantly. A meta-analysis of 15 studies comparing pre-and post-ESA therapy VO_{2peak} values showed an average increase of 23.8% (95% Confidence Interval (CI), 18.56-28.97) (Johansen et al., 2010). However, Painter *et al.* (2002) found that VO_{2peak} remained low compared to age-predicted values even after hematocrit levels were corrected to near normal with ESAs (mean, 56.8±20.6% of age and sex predicted values). Correction of hemoglobin levels beyond 30% typically does not provide any additional improvements in exercise tolerance. Painter *et al*. (2002) found that increasing hemoglobin levels from 33% to between 40-42% did not change VO_{2peak} in 12 HD patients (19.8±6.2 vs.19.9±6.7 $ml \cdot kg^{-1} \cdot min^{-1}$ at baseline and at 5 months, respectively). Therefore, although anemia likely plays a contributory role, it is clearly not the only factor associated with reduced exercise tolerance in HD patients.

Performance-based measures of physical function provide an indication of cardiorespiratory fitness, strength, and flexibility (Painter, 2005). These measures are often used in place of maximal and submaximal exercise testing since many ESRD patients are unable to perform symptom-limited exercise. Results of performance-based measures also confirm low levels of physical functioning among individuals with ESRD. The mean sit-to-stand score, an indicator of quadriceps muscle strength, in 111 HD patients was 29.3±12.5 seconds; approximately 15±30% of normal age-predicted values (Painter et al., 2000b). Similarly, in 131 HD patients, gait speed, an indicator of lower extremity function, was found to be 66±17.5% (90.5±25.6 cm/s) of normal age expected values (Painter et al., 2000b). Johansen *et al.* (2001b) also found that measures of gait speed and chair-rising time in 39 HD patients were significantly lower than normative values for healthy age-matched controls (gait speed dialysis=115±34 cm/s, healthy=139±5 cm/s; chair-rising time dialysis=16.5±9.9 sec, healthy=12.2±4.5 sec).

Self-reported physical function further confirms low levels of physical function among HD patients. Self-report instruments are the most commonly employed measure of physical function. In particular, the Medical Outcomes Study Short Form 36-item questionnaire (SF-36) is a well-established, frequently used questionnaire that assesses self-reported domains of health status among those with chronic diseases (Painter, 2005). The questionnaire consists of 8 scales;

physical functioning (PF), role functioning/physical, bodily pain, general health, vitality, social functioning, role functioning/emotional and mental health. Each scale is scored from 0-100, with higher scores indicating greater function. The mean PF score in a large population study of 16,755 HD patients was 41.4±30.0 (Diaz-Buxo, Lowrie, Lew, Zhang, & Lazarus, 2000). More strikingly, values as low as 30.4±20.8 and as high as 67.2±22.6 have been reported in low functioning and high functioning HD patients, respectively (Painter et al., 2000a). Therefore, on average, even high functioning HD patients report lower levels of physical function than those in the general Canadian (82.3±16.9) (Hopman et al., 2000) and U.S. population (84.2±23.3) (Diaz-Buxo et al., 2000). These results are in agreement with numerous other studies in the HD population which have shown similar scores of poor physical function on the PF scale (DeOreo, 1997; Johansen et al., 2001a, b; Johansen et al., 2003a; O'Hare et al., 2003; Painter et al., 2000a).

2.1.3 The Uremic Syndrome and Physical Function

2.1.3.1 Skeletal Muscle Dysfunction

Reductions in physical function and exercise capacity are attributed to various central and peripheral factors that result primarily from uremic neuropathies and myopathies (Kouidi et al., 1998). Uremic neuropathies are "caused by primary axonal degeneration with segmental demyelination" (Kouidi et al., 1998). Uremic myopathies are a result of ensuing structural and functional abnormalities of the skeletal muscle fibres (Johansen et al., 2003b; Kouidi et al., 1998); however, the relative contribution of each to skeletal muscle dysfunction remains elusive (Campistol, 2002).

Muscle dysfunction contributes to reduced work capacity in HD patients (Kouidi et al., 1998). In fact, muscle abnormalities may be the most important limiting factor for work capacity in this population (Diesel, Noakes, Swanepoel, & Lambert, 1990). Muscle dysfunction likely occurs as a result of the changes associated with the altered internal environment characteristic of uremia, including: high serum calcium levels, azotemia, acidaemia, low level of carnitine, and or secondary hyperparathyroidism (Kouidi et al., 1998). Structural and functional skeletal muscle abnormalities, particularly skeletal muscle atrophy and impaired muscle oxidative metabolism, appear to occur frequently in HD patients (Kouidi, 2001). Muscle atrophy, or a reduction in cross-sectional area of individual muscle fibres, is a significant problem in HD patients. Compared with reported values for healthy sedentary age-matched individuals, HD patients tend to have a considerably reduced mean muscle fibre area (4,150±246 vs. 2,548±46.3μm^2) (Kouidi et al., 1998). Both Type I and Type II fibre size are reduced, however it appears that Type II fibres are more affected. The usual ratio of Type I to Type II fibres in the vastus lateralis is 1:2, yet, morphometric analysis showed a 1:1 ratio among HD patients (n=7) (Kouidi et al., 1998). Similar levels and patterns of muscle atrophy in the HD population have been previously reported (Ahonen, 1980; Bautista, Gil-Necija, Castilla, Chinchon, & Rafel, 1983). The development of muscle atrophy in HD patients may be associated with uremic peripheral neuropathy (Kouidi, 2001), but it is likely that physical inactivity plays a large contributory role due to the sedentary nature of this population (Kouidi et al., 1998). Slowed nerve conduction velocity is a frequent occurrence in uremic individuals (Fraser & Arieff, 1988; Heidbreder, Schafferhans, & Heidland, 1985; Kouidi et al., 1998) and is suggestive of peripheral nerve damage (Kouidi et al., 1998). Compared with values of 56.9±4.0 m/s in healthy individuals (Kominami, Tyler, Hampers, & Merrill, 1971), HD patients (n=7) showed substantively reduced nerve conduction velocities of 40.3±3.0 m/s in the peroneal nerve (Kouidi et al., 1998). Further evidence of peripheral neuropathy among HD patients was indicated by findings of small group atrophy and clusters of one fibre type instead of the normal mosaic of fibre types, which is characteristic of denervation atrophy and reinnervation, respectively (Kouidi et al., 1998). Another degenerative change in muscle structure reported in individuals on HD (n=22) is a reduced amount of contractile tissue.

Muscle biopsies have shown that HD patients have significantly less contractile tissue and significantly more non-contractile tissue than healthy sedentary age-matched individuals (n=17) (7.2±3.1 vs. 9.1±2.0 cm^2 and 3.7±2.3 vs. 1.8±0.5 cm^2, respectively) (Johansen et al., 2003b). Ultrastructural analysis has also revealed degenerative changes in mitochondria and capillaries (Diesel et al., 1993; Kouidi et al., 1998).

Suboptimal oxidative energy metabolism has been demonstrated in the skeletal muscle of dialysis patients (Bergstrom & Hultman, 1969; Moore et al., 1993b). Compared with healthy individuals, dialysis patients often have excess lactic acid production and a decreased intracellular pH for the same-intensity exercise (Campistol, 2002; Lundin et al., 1987; Moore et al., 1993b; Parrish, 1981). Further, dialysis patients have also been found to have increased glycogen deposition in their muscle fibres (Diesel et al., 1993; Kouidi et al., 1998). The presence of impaired carbohydrate metabolism among dialysis patients has been suggested to be a result of alterations in mitochondrial metabolism (Moore et al., 1993b; Penpargkul, Bhan, & Scheuer, 1976). However, functional integrity of mitochondria in uremic individuals has been established using ^{31}P-magnetic resonance spectroscopy (Campistol, 2002; Miró et al., 2002; Moore, Bertocci, & Painter, 1993a). Instead, the deficiency in carbohydrate metabolism may stem from abnormal muscle oxygen conductance from muscle microcirculation to the mitochondria (Campistol, 2002; Moore et al., 1993b). Impaired muscle oxidative metabolism may be a factor affecting physical function in this population since it likely contributes to decreased oxygen-dependent metabolism in the muscle and is associated with muscle weakness and reduced aerobic capacity (Chikotas et al., 2006; Johansen et al., 2003b; Painter, 1994).

Considering the numerous pathological changes that occur in the muscles of HD patients, it is not surprising that their muscle performance is considerably impaired. Muscle strength among individuals with ESRD is typically 50% of their healthy counterparts (Campistol, 2002).

Measures of ankle dorsiflexor muscle strength determined by maximal voluntary isometric contractions indicated that HD patients (n=38) had significantly reduced strength in their anterior leg muscles compared to age-matched healthy counterparts (n=19) (169.6±65.5 vs. 217.7±69.1 N) (Johansen et al., 2003b). Reductions in strength seriously impact functional capacity. Diesel *et al.* (1990) found that isokinetic muscle strength correlated significantly with VO_2 peak, exercise duration, peak ventilation, and peak blood lactate concentration (r=0.73 to r=0.84). No significant correlations existed, however, between hemoglobin concentration, total blood hemoglobin content, or hematocrit and these variables. Therefore, isokinetic muscle strength was suggested to be a major predictor of exercise capacity, having greater predictive ability than factors determining blood oxygen carrying capacity (Diesel et al., 1990). Further, both muscle atrophy and muscle strength have been found to be significantly related to gait speed (r=0.61and r=0.47, respectively) (Johansen et al., 2003b). Therefore, it is likely that impaired skeletal muscle structure and function are major factors influencing the decreased exercise tolerance and physical function of uremic patients.

2.1.3.2. Cardiac Dysfunction

Cardiac dysfunction is common among uremic individuals due to the effects of autonomic neuropathy and cardiomyopathy. In chronic uremia, cardiomyopathy can result from left ventricular (LV) pressure and volume overload and typically results in one, or a combination of LV hypertrophy, LV dilation, and LV systolic and diastolic dysfunction (Parfrey, 2000). Unfortunately, the hemodynamic milieu of hemodialysis and the use of arterio-venous fistulas favour the development of LV hypertrophy and LV dilation. Other factors including myocardial ischemia, fibrosis, and biochemical abnormalities associated with chronic uremia also contribute to left ventricular hypertrophy and dysfunction (Kouidi, 2001). Cardiomyopathy is considered to be a major contributor to LV hypertrophy and ischemic heart disease in renal failure patients since LV hypertrophy (London et al., 1987) and ischemic heart disease (Roig et al., 1981; Rostand, Kirk, & Rutsky, 1984) have been found in HD patients who have no signs of coronary artery disease or hypertension. Rostand *et al.* (1984) found that significant narrowing of the coronary arteries did not exist in approximately 50% of patients with clinical signs of ischemia. Echocardiography showed that HD patients with no signs of coronary artery disease had significantly enlarged left ventricular end-diastolic diameter (London et al., 1987) and left ventricular mass (Deligiannis, Kouidi, Tassoulas, Gigis, Tourkantonis, & Coats, 1999a) compared with healthy controls (5.58±0.60 cm vs. 5.05±0.5 cm; 226±70 g vs. 151±29 g, respectively). These LV structural abnormalities can result in impaired cardiac function since LV hypertrophy leads to LV dilation and causes LV dysfunction, which ultimately reduces ejection fraction, stroke volume, and cardiac output (Deligiannis *et al.*, 1999a). Additionally, independent of age, diabetes, and ischemic heart disease, the presence of LV hypertrophy, LV dilation, or systolic dysfunction at the initiation of dialysis has been associated with an almost three-fold increased risk of subsequent heart failure; a primary cause of mortality in HD patients (Foley et al., 1995). A mismatch between capillary supply and cardiomyocytes has also been found in the hearts of uremic patients (Amann, Breitbach, Ritz, & Mall, 1998). The capillary density (the ratio of capillary-to-myofiber) in the myocardium of dialysis patients (n=10) was significantly lower than in controls (n=10) (2,898±456 vs. 1,483±283mm/mm^3). This would likely exacerbate pre-existing ischemia and effectively reduce exercise tolerance.

In vitro studies have shown that uremic toxins are capable of depressing myocardial function (Horl, 2004; Penpargkul, Kuziak, & Scheuer, 1975; Raine, Seymour, Roberts, Radda, & Ledingham, 1993; Scheuer & Stezoski, 1973). One uremic toxin in particular, parathyroid hormone, has been shown to have several adverse effects on myocardium cell function and metabolism (Horl, 2004). Elevation of parathyroid hormone is an almost universal finding in uremic patients and thus may be an index of uremia (London et al., 1987). In HD patients, secondary hyperparathyroidism has been implicated in the pathogenesis of myocardial dysfunction via calcific myocardiopathy, metastatic calcification of the ventricular myocardium (Cozzolino, Brancaccio, Gallieni, & Slatopolsky, 2005; Horl, 2004; How, Mason, & Lau, 2008; London et al., 1987), and left ventricular abnormalities (Amann, Rychlik, Miltenberger-Milteny, & Ritz, 1998; London et al., 1987).

Autonomic control of the heart is affected in uremic patients largely due to central and peripheral uremic neuropathy and generally manifest as increased sympathetic and reduced parasympathetic activity (Deligiannis, Kouidi, & Tourkantonis, 1999; Kouidi, 2001). Consequently, HD patients will often experience abnormal responses in blood pressure (as hypotension) and/or heart rate (as episodes of tachycardia) during dialysis (Deligiannis et al., 1999; Kouidi, 2001). Cardiac autonomic insufficiency may also result from cardiac nerve fibre damage, particularly the Vagus nerve (Campese, Romoff, Levitan, Lane, & Massry, 1981). Psychological tension, stress, electrolyte shifts, anaemia, and dysfunction of pacemaker cells have also been shown to influence cardiac autonomic activity in dialysis patients (Campese et al., 1981; Deligiannis et al., 1999; Kouidi, 2001). Deligiannis *et al.* (1999) found that heart rate variability (HRV) index, a quantitative measure which reflects the level of parasympathetic activity, was reduced by 42% in HD patients compared with non-uremic individuals ($p<0.05$). Furthermore, 62% of HD patients showed abnormal cardiac vagal activity (i.e. HRV < 25; the St. George HRV index, normally ≥ 25) compared with 10% of controls ($p<0.05$) (Deligiannis *et al*., 1999). Autonomic dysfunction among HD patients was further demonstrated by Campese *et al.* (1981) who found that HD patients (n=16) had an abnormal Valsalva ratio and an abnormal response to hand-grip exercise compared with patients with chronic illness but normal renal function (n=15) and healthy individuals (n=60). A Valsalva ratio reflects the relative magnitude of an individual's heart rate response to a Valsalva maneuver; it is the ratio between the longest R-R interval during the release phase and shortest R-R interval during the strain phase. Valsalva ratios were significantly lower in dialysis patients compared to both the chronic illness patients and healthy participants (1.62±0.09 vs. 2.10±0.05 and 2.00±0.13, respectively). The greater level of autonomic dysfunction shown by dialysis patients compared to those with a chronic illness but normal renal function suggests that the disturbances may be related to uremia itself or its consequences rather than the state of chronic illness (Campese et al., 1981). The increment in blood pressure and heart rate during the hand-grip test, which is associated with increased heart rate, cardiac output, and arterial blood pressure, was also significantly lower in dialysis patients than the control group (21±2 vs. 28±1mmHg). Further, 71% of dialysis patients who had a low Valsalva ratio also had an abnormal heart rate response to the hand-grip exercise, suggesting a disturbance in the vagal pathways in uremic individuals (Campese et al., 1981). Over-activity of the sympathetic nervous system is noted to be strongly associated with instability of the myocardium (Cripps, Malik, Farrell, & Camm, 1991). Additionally, HD patients tend to have areas of the myocardium that are electrically unstable and predisposed to dispersion of repolarization and alteration in the action potential morphology because of active inflammation, fibrosis or ischemia of the myocardial tissue (Kouidi, 2001). Therefore, it appears that the increased sympathetic activity, impaired vagal activity, and electrical instability that accompany renal failure facilitate arrythmogenesis. Not surprisingly, the proportion of HD patients who experience arrhythmias is reported to be almost 60% (Deligiannis et al., 1999; Kouidi, 2001).

Autonomic dysfunction and the ensuing abnormalities in heart rate and blood pressure likely impair the cardiac response to exercise. These abnormalities may also contribute to the low exercise capacity and physical function of HD patients (Deligiannis *et al.*, 1999a).

2.1.4 Relationship between Mortality and Physical Activity, Physical Function, and Exercise Capacity

Many variables have been identified as predictors of mortality in the ESRD population. Those of particular concern are aerobic capacity, physical function, and physical activity levels since they typically are significantly reduced in the ESRD population. Using a minimal multivariate experimental model, VO_{2peak} was found to be a strong predictor of mortality (Sietsema, Amato, Adler, & Brass, 2004). In 175 HD patients, those who had a VO_{2peak} greater than 17.5 $ml \cdot kg^{-1} \cdot min^{-1}$ had a significantly better crude survival rate at three years than those with a VO_{2peak} less than that value (95% vs. 78%, respectively); this was confirmed by univariate Kaplan-Meier analysis.

A similar relationship was reported between mortality and low levels of self-reported physical function as measured by the SF-36 physical component summary (PCS) score, which is the combination of the physical components of the 8 scales of the SF-36. Knight, Ofsthun, Teng, Lazarus, and Curhan (2003) found that in 14,815 HD patients, low self-reported physical function was associated with increased mortality in a graded fashion across a spectrum of physical function scores. Multivariate-adjusted hazard ratios (HR) indicated that those with a PCS score < 20, 20-29, and 30-39 had a 97% (95% CI, 1.64-2.36), 62% (95% CI, 1.36-1.92), and 32% (95% CI, 1.11-1.57) increased risk of mortality, respectively, compared to those who had a PCS score > 50. Additionally, a six-month decline in reported physical function appeared to further increase mortality as a 10-point decrease in the PCS score was significantly associated with additional increased mortality risk beyond baseline risk (HR=1.25, 95% CI, 1.18-1.33 per 10-point decline in PCS score) (Knight *et al.*, 2003). Further, using the same data set, Lowrie, Curtin, LePain, and Schatell (2003) determined that every point increase in the PCS score was associated with a 2% reduction in mortality rate (p<0.001) and that PCS was more closely associated to odds of death than many other relevant clinical variables (i.e. iron, hemoglobin, phosphorus); only low serum albumin, high creatinine, and increasing age were more predictive. A previous study by DeOreo (1997) corroborated these results reporting that those with a PCS scores less than the median (<34) were twice as likely to die and 1.5 times as likely to be hospitalized (odds ratio (OR)=2.03; 95% CI, 1.44-2.85, p=0.0003, chi-squared and OR=1.67; 95% CI, 1.43-1.95, p=0.0003, respectively). Similarly, it was found that a 5-point increase in the PCS score conferred a 10% survival advantage (95% CI, 1.1-1.8, p=0.02).

Low levels of physical activity have also been associated with increased mortality among HD patients. Those who were sedentary showed a 62% greater risk for mortality over 1 year compared with non-sedentary HD patients (HR=1.62; 95% CI, 1.16 to 2.27) (O'Hare et al., 2003). Using the same data set, the DMMS Wave 2, Stack, Molony, Rives, Tyson, and Murthy (2005) reported that regular exercise among HD patients was associated with significantly lower all-cause and cardiovascular mortality. When adjusted for demographic factors, co-existing medical conditions, and laboratory measures of mortality, HD patients that participated in exercise 2-3 or 4-5 times per week had a 26% and 30% survival advantage, respectively, over those who exercised once a week or less (95% CI, 0.58-0.95, $p<0.05$ and 0.47-1.04, p=0.07). Additionally, the relative risk (RR) for cardiovascular death in HD patients who participated in exercise 2-3 times/week was significantly lower than those exercising once a week or less (RR=0.72, 95% CI 0.53-0.98). Interestingly, participating in daily exercise did not appear to confer any survival advantage (RR=1.06, 95% CI 0.86-1.30).

2.1.5 Benefits of Physical Activity

Exercise intervention programs successfully improve aerobic capacity, cardiovascular function, muscle strength, physical performance, and enhance psychological well-being (Cheema & Singh, 2005; Johansen, 2007; Painter, 2005). Exercise programs can increase VO_{2peak} values

20-40% in HD patients following 3 to 12 months of training (Kouidi, 2001). In the HD population, oxygen consumption tends to be limited at the peripheral level and thus is not likely to be optimally enhanced with aerobic training alone (Cheema & Singh, 2005). Combined aerobic and resistance training have shown to be more effective in increasing aerobic capacity than aerobic training alone. Substantive mean gains of 48% in VO_{2peak} were reported for 7 HD patients following a 6-month combined aerobic and resistance exercise program (17.7±5.0 to 26.2±8.0 $ml \cdot kg^{-1} \cdot min^{-1}$, $p<0.05$) (Kouidi et al., 1998). Similar improvements in VO_{2peak} were also reported by Deligiannis *et al.* (1999) who found that a 6-month, thrice weekly combined exercise rehabilitation program improved VO_{2peak} by 41% in 30 HD patients (17.6±6 to 24±7 $ml \cdot kg^{-1} \cdot min^{-1}$, $p<0.05$); these increases are greater than any gains achieved with aerobic exercise training alone (Johansen, 2007). While such impressive results demonstrate the potential improvement in VO_{2peak} that can result from combined exercise programs, mean gains of around 20% are more widely reported (Konstantinidou, Koukouvou, Kouidi, Deligiannis, & Tourkantonis, 2002; Ouzouni, Kouidi, Sioulis, Grekas, & Deligiannis, 2009; Petraki, Kouidi, Grekas, & Deligiannis, 2008). Aerobic training alone typically elicits changes in VO_{2peak} of approximately 17% among the HD population (Johansen, 2007). On the other hand, some studies have reported no significant changes in VO_{2peak} following aerobic training (Akiba et al., 1995; Goldberg et al., 1983). The lack of effect observed in these studies may have been due to a prescription of exercise that was of insufficient intensity (< 60% VO_{2peak}) (Goldberg et al., 1983) and/or duration (10-20 min) (Akiba et al., 1995).

Regular exercise provides many cardiovascular benefits that enhance cardiac performance and confer a survival advantage including improvements in resting blood pressure, and LV structure and function (Deligiannis et al., 1999a; Deligiannis, Kouidi, Tassoulas, Gigis, Tourkantonis, & Coats, 1999b; Kouidi, 2001). In a study of 38 HD patients, 6 months of combined aerobic and strength training exercise on non-dialysis days significantly improved LV mass by 6% and LV end-diastolic volume (LEDV) by 4% (Deligiannis *et al.*, 1999a). Left ventricular remodeling was associated with enhanced cardiac function at rest; ejection fraction (EF) and stroke volume index (SVI) significantly increased by 5% and 14%, respectively. Additionally, the hemodynamic changes with submaximal exercise (70-80% Heart $Rate_{max}$) were significantly enhanced compared with pre-training responses; EF, SVI, and cardiac output index increased by 70%, 73% and 50%, respectively. Such remarkable results may not be common place following an exercise intervention among the HD population. The exercise program in this study was quite intense including up to 70 min of calisthenics, step, and strength exercises 3 times per week, and may not be appropriate for all of the ESRD population. However, in the same study, similar favourable changes were also elicited, although to a lesser degree, by a moderate intensity home exercise program (Deligiannis *et al.*, 1999a). While no significant changes were found in LV structure, cardiac function improved significantly. Following the 6-month training program, changes in EF, SVI and cardiac output index during submaximal exercise (70-80% Heart $Rate_{max}$) increased significantly by 63%, 113%, and 28%, respectively, compared to pre-training testing. Such improvements in the hemodynamic response to exercise may have serious implications for exercise capacity and physical function since LV EF has recently been shown to correlate well with VO_{2peak} ($r=0.701$, $p<0.001$) (Kouidi, Grekas, & Deligiannis, 2009).

Regular aerobic exercise can also improve blood pressure control in HD patients primarily by reducing peripheral vascular resistance and decreasing plasma volume (Anderson, Boivin, & Hatchett, 2004; Deligiannis et al., 1999a; Goldberg et al., 1986; Hagberg et al., 1983; Miller, Cress, Johnson, Nichols, & Schnitzler, 2002; Ouzouni et al., 2009; Petraki et al., 2008). In a group of 13 HD patients, 3 months of intra-dialytic aerobic exercise reduced 44-hour inter-dialytic ambulatory systolic and diastolic blood pressure by 9% (138.4±19.6 mmHg vs.

125.7±20.0 mmHg, $p<0.05$) and 10% (83.2±10.2 mmHg vs.74.7±9.0 mmHg, $p<0.05$), respectively (Anderson et al., 2004). Combined aerobic and resistance training has shown to elicit a similar response among HD patients, Deliginnias *et al.* (1999b) reported significant decreases in diastolic and systolic blood pressure following 6 months of thrice weekly combined training (systolic=6%, $p<0.01$; diastolic=9%, $p<0.01$). Even in the absence of significant changes in resting blood pressure, participation in intra-dialytic exercise has been shown to improve blood pressure control by reducing required antihypertensive medications. Miller *et al.* (2002) reported a 36% reduction in antihypertensive medications among 24 HD patients following 6 months of low-intensity aerobic exercise.

Prolonged aerobic exercise can also improve cardiac autonomic outflow dysfunction resulting from uremic neuropathy by significantly increasing cardiac vagal activity and improving the electrical stability of the myocardium. Deligiannis *et al*. (1999) showed that 6 months of aerobic training, on non-dialysis days, resulted in a 31% increase in HRV index compared with baseline values ($p< 0.05$) and a 33% decrease in the number of HD patients experiencing arrhythmias ($p< 0.05$). Similar results were reported in a randomized-control trial by Kouid *et al*. (2009) in which the number of indicators of risk of sudden cardiac death were significantly lower among those in the exercise group after training compared with sedentary HD patients. Additionally, after training the number of patients in the exercise group experiencing arrhythmias, as detected by 24-hour Holter monitoring recordings, decreased by 6.8% ($p<0.05$) from baseline (Kouidi et al., 2009).

Exercise training can also significantly improve muscle structure and function in HD patients. In addition to improved muscle structure, muscle fibre cross-sectional area, muscular endurance, and muscular strength increased following a 6-month combined exercise training program (Kouidi et al., 1998). Mean muscle fibre cross-sectional area increased 30% ($p \leq 0.05$), with the greatest increases occurring in type II fibres. The ratio of type I to type II fibres shifted toward that in the healthy controls and structural abnormalities were minimized such that the muscle looked relatively normal. These morphological changes were accompanied by significant increases in VO_{2peak} (48%) and maximal strength of the lower limbs (40.2% right leg, 55.7% left leg). However, this program was intense, consisting of 90 minutes of combined aerobic and resistance exercise sessions, 3 times per week. Significant improvements in muscle strength and muscle atrophy have also been accomplished with lower intensity resistance programs (Headley et al., 2002; Johansen et al., 2006). Three months of low-intensity intra-dialytic resistance training significantly increased quadriceps muscle cross-sectional area (47±13.9 to 49.1±13.5cm^2) and the three-repetition maximum for knee extension (14.0±8.4 to 22.6±11.6 lb), hip abduction (8.5±5.2 to 15.4±6.9 lb), and hip flexion (7.6±5.3 to 13.7±6.8 lb) (Johansen et al., 2006). Similarly, a 12.7±3.6% increase from baseline in isokinetic peak torque of the dominant leg extensor at 90°/s was reported following a 12-week low-intensity resistance training program in HD patients (n=10) (139.1±19.3 vs. 124.1±18.7 nm (SEM), $p<0.05$) (Headley et al., 2002). Aerobic exercise is not considered to be highly anabolic; most studies employing aerobic exercise have not elicited significant improvements in muscle strength (Kopple et al., 2006; Moore et al., 1993b). However, in a recent study of 24 HD patients, a low-intensity intra-dialytic cycling program significantly improved muscle leg-press strength by 16% and muscle fatigability by 43% (Storer et al., 2005). The improvements evoked by aerobic training in these patients were attributed to the potential for large adaptations due to an initial deconditioned state. Therefore, low intensity exercise may provide adequate resistance for deconditioned HD patients to improve muscle function (Storer et al., 2005). Further, aerobic training may induce a cellular pattern of change in mRNA levels that promotes hypertrophy. On average, insulin-like Growth Factor (IGF)-I receptors increased 41% (p=0.013) and mRNA myostatin, an anti-hypertrophic factor, decreased 51% (*p*=0.039) following 9 weeks of aerobic training in10 HD patients (Kopple et al., 2006). Additionally, 6 months of aerobic training was found to increase mean cross-sectional muscle fibre area (46%, *p*<0.01), decrease the proportion of atrophic fibres (-36%, -37%, and -30% in type I, IIa, and IIx fibres, respectively, *p*<0.05), and to improve the capillarization in the skeletal muscle (Sakkas et al., 2003) .

Gains in functional endurance and muscular performance have also been reported with regular exercise in HD patients. In a study by Painter *et al.* (2000b), HD patients (n=286) showed significant increases in habitual gait speed (3%), maximum gait speed (2%), and sit-to-stand speed for 10 repetitions (23%) following 8 weeks of low-intensity combined aerobic and resistance home exercise and a subsequent 8 weeks of in-centre intra-dialytic cycling (16 weeks total). In the same study they also reported significant increases of 12% in self-reported physical function as measured by the physical scales of the SF-36. These results have been corroborated by Parsons, Toffelmire, and King-VanVlack (2006) who reported significant gains of 14% in 6-minute walk distance among 13 HD patients following 20 weeks of low-intensity intra-dialytic aerobic exercise. The findings of the above studies suggest that vigorous activity is not necessary to achieve gains in physical function in the HD population. A recent review reporting the impact of extra-dialytic and intra-dialytic exercise programs on aerobic exercise capacity, functional exercise endurance, and cardiovascular outcomes in individuals with ESRD found that low- or moderate-intensity exercise was adequate to elicit substantive improvements in exercise endurance and confer cardiovascular benefits (Parsons & King-VanVlack, 2009).

Regular exercise can also alleviate depression in the ESRD population. Following a 10-month intra-dialytic exercise program, 18 HD patients showed a significant reduction of 39.4% (*P*<0.001) in the Beck Depression Index (Ouzouni et al., 2009). Similar reductions (42%, *p*≤

0.01) in self-reported depression were also reported following 12 months of aerobic exercise among HD patients (Goldberg et al., 1983; Goldberg et al., 1986).

Considering the aforementioned, there is a great potential for mortality reduction in this cohort as a result of exercise participation since exercise has the capacity to improve risk factors of cardiovascular disease, the number one cause of mortality among ESRD patient. Additionally, exercise has the potential to improve functional capacity and health-related quality of life.

2.2 Determinants of Physical Activity and Exercise Participation

A theoretical attitude-behaviour framework is usually employed to understand and enhance physical activity participation. The most commonly employed strategies are the Health Belief Model, the Theory of Planned Behaviour, the Social Cognitive Theory, and the Transtheoretical Model (Bauman, Sallis, Dzewaltowski, & Owen, 2002) . The Health Belief Model (Rosenstalk, 1974) proposes that a person will adopt a health-related action depending on the perceived susceptibility and severity of a condition, and the perceived barriers and benefits of an advised action. The Social-Cognitive Theory (Bandura, 1986) postulates that, "one's perceived capabilities operate together with goals, outcome expectations, and perceived environmental barriers and facilitators in the regulation of human motivation, behaviour, and well-being." The Theory of Planned Behaviour (Ajzen, 1991) is based on the idea that behaviours are determined by intentions which are, in turn, determined by attitudes, subjective norms, and perceived behavioural control. The Transtheoretical model (Prochaska & DiClemente, 1984) views change as a process involving progress through a series of 5 stages and is used to better understand how people progress toward adopting and maintaining health behaviour change. Physical activity is a complex multi-dimensional phenomenon determined by the interaction of a diverse set of variables and therefore is unlikely to be encompassed by a single theory; rather it demands a multi-level ecologic approach (Bauman et al., 2002). In examining the use of attitude-behaviour models in the promotion of physical activity *past behaviour, self-efficacy, barriers to physical activity, and outcome expectancies* have been commonly cited as useful predictors of physical activity levels among adults (Ayotte, Margrett, & Hicks-Patrick, 2010; McAuley et al., 2007). However, although these variables are recognized as useful predictors, Godin and Sheppard (1990) have reported that attitude-behaviour models rarely explain more than 35% of the variance. They suggested that perhaps these models focus too much on the factors influencing the initiation of physical activity rather than factors which accompany and contribute to its persistence. Bandura (1997) expressed similar sentiments, suggesting that when trying to promote a behaviour it is important to differentiate between belief in the efficacy of a preventative method and belief in one's efficacy to use the method consistently. It is unlikely that a person would undertake a health promoting behaviour if they seriously doubted their ability to adhere to that behaviour (Bandura, 1997).

A diverse range of intrapersonal, social/cultural, and environmental factors have been identified to operate within these theories (Bauman et al., 2002). Individual-level variables, particularly self-efficacy, demonstrate the strongest and most consistent associations with physical activity behaviour (Bauman et al., 2002). Self-efficacy, which refers to a person's judgment of their capability to perform a specific task, is the primary determinant of consistent, health promoting levels of physical activity (Bandura, 1997). Exercise self-efficacy was reported to be the strongest and most consistent predictor of exercise behaviour in healthy individuals, explaining 10-25% of the variability in exercise behaviour (McAuley, 1993; McAuley et al., 1994; McAuley et al., 2003a, McAuley et al., 2007). Given this significant influence of self-efficacy on exercise behaviour, some investigators suggest that it be targeted as an outcome in and of itself (McAuley, Lox, & Duncan, 1993).

2.3 Self-Efficacy

Self-efficacy was developed within the framework of the Social Cognitive Theory which posits that beliefs of personal efficacy are a quintessential part of human motivation and action and thus play a central role in behaviour change (Bandura, 2004). More simply, unless people believe that they can produce a desired outcome, they have little incentive to act or persevere when faced with adversity. Self-efficacy is likely a key determinant of physical activity because it affects health behaviour both directly and indirectly by influencing other determinants, particularly perceived barriers, self-regulatory behaviours, and outcome expectancies (Ayotte et al., 2010). In a sense, efficacy beliefs act as motivational regulators since they influence goals, aspirations, and the level of commitment to an activity (Bandura, 1997; Bandura, 2004). Those with stronger levels of self-efficacy tend to set higher goals for themselves and demonstrate greater commitment to them. Self-efficacy beliefs also shape the outcomes people expect their efforts to achieve (Bandura, 2004). Those with high self-efficacy tend to expect favourable outcomes while those with low self-efficacy often expect poor outcomes. Further, self-efficacy determines how barriers are viewed. Individuals with low efficacy are easily convinced of the fruitlessness of their efforts if faced with a challenge, and quickly give up. Conversely, those with high efficacy tend to believe that they will prevail when faced with an impediment and approach the task with greater levels of perseverance. Thus, self-efficacy plays a pivotal role in determining which activities will be attempted, how much effort will be devoted to a task, and the level of persistence in the face of adversity (Bandura, 1997). This has serious implications for health promotion since those with higher efficacy beliefs are more likely to initiate and maintain a given behaviour.

The construct of self-efficacy has been applied to, and shown to have a significant influence on many health promoting behaviours such as smoking-cessation relapse (Baldwin et al., 2006), pain experience and management (Asghari & Nicholas, 2001), control of eating and weight (Gallagher, Jakicic, Napolitano, & Marcus, 2006), and cardiac rehabilitation programs (Carlson et al., 2001; Millen & Bray, 2008; Sniehotta, Scholz, & Schwarzer, 2005). Additionally, self-efficacy has been linked to various aspects of positive mental health including reduced anxiety and depression (McAuley, Pena, & Jerome, 2001). An important caveat of self-efficacy is that it operates in conjunction with a person's perceived outcome expectancies. Should a person believe that a health behaviour will not lead to a desirable outcome, it is unlikely that he/she will engage in such behaviours regardless of his/her level of efficacy (Bandura, 1977). However, more recently, Bandura (1997) has argued that efficacy beliefs are likely more important than outcome expectancies in predicting behaviour change since a person's emotional state and actions are based more on beliefs than an objective assessment. He suggests that individuals' beliefs of their capabilities will often better predict behaviour than what they are actually able to accomplish, pointing out that the belief that a behaviour will elicit a positive outcome may be more important than whether such a positive outcome has previously been achieved. Therefore, it may not be relevant to possess the necessary knowledge and skill to execute a task since having the confidence to adopt a behaviour may be enough to initiate it (Bandura, 2004).

Self-efficacy is a multi-dimensional construct differentiated across multiple domains of functioning and should be conceptualized in a situation specific manner (Bandura, 1997). Accordingly, self-efficacy, particularly regarding physical activity, is often broken down into task self-efficacy, the confidence one has in his or her ability to perform a specific task, and barrier self-efficacy, one's confidence to be able to perform a certain task under challenging conditions.

Expectations of one's self- efficacy are influenced by 4 sources of information; *enactive mastery experiences*, *vicarious experience*, *verbal persuasion, and physiological and effective* *states* (Bandura, 1997). *Enactive Mastery Experiences,* or successfully completing a given activity, builds self-efficacy by affirming that a person possesses the capabilities to succeed in a comparable activity. *Vicarious Experience*, can enhance one's self-efficacy because seeing others who are perceived to be similar to oneself manage task demands successfully instills a sense of personal competency for similar activities. *Verbal Persuasion,* may boost an individual's perceived self-efficacy by persuading an individual that he/she possesses the capabilities to master a given activity. Finally, perception of *Physiological and Affective States* allows individuals to make inferences about their personal strengths and vulnerabilities. *Enactive Mastery Experience* is the most influential source of efficacy information because it provides the most reliable evidence of whether a task can be completed successfully (Bandura, 1997).

2.3.1 Exercise Self-Efficacy and Physical Activity

2.3.1.1. General Population

Epidemiological research has found that among a wide array of personal, social/cultural, and environmental variables, self-efficacy is one of the most consistent and reliable predictors of physical activity (Sallis et al., 1986; Sallis et al., 1992; Trost, Owen, Bauman, Sallis, & Brown, 2002). In the promotion of physical activity, self-efficacy appears to be phase-specific since different actions and situations present distinct barriers and challenges that require a unique set of self-efficacy beliefs to succeed (Schwarzer, 2008). The Health Action Process Approach (Schwarzer, 1992) categorizes self-efficacy into task self-efficacy (confidence to successfully perform a specific action), maintenance self-efficacy (confidence to deal with barriers that arise during maintenance period), and recovery self-efficacy (confidence to resume action when interrupted). Consequently, specific self-efficacy beliefs operate in a different manner from one another and play more salient roles at different points in the exercise process (i.e. adoption, maintenance, dropout, resumption).

Exercise self-efficacy, which is a task specific self-efficacy, is the level of confidence an individual possesses in his/her ability to perform a particular exercise behaviour (Sherwood & Jeffery, 2000). Exercise intervention studies have demonstrated this concept of phase-specificity, reporting that exercise self-efficacy has greater saliency at distinct stages in the exercise process (McAuley, 1992; McAuley et al., 1993; McAuley, 1993; Oman & King, 1998). Exercise-self efficacy appears to play a prominent role in the adoption and adaptation stages of the exercise process but is less important in the maintenance stage (McAuley, 1992; Oman & King, 1998). Among a group of 65 sedentary middle-aged adults who participated in a 5-month exercise program, exercise self-efficacy significantly predicted exercise frequency (attendance) and intensity over the first 3 months, but it could not successfully predict exercise participation at 5 months (McAuley, 1992). Past behaviour (attendance) was a more powerful predictor of future behaviour than self-efficacy at 5 months (McAuley, 1992). However, in a follow-up study the relationship between self-efficacy and exercise participation was examined in a more demanding context; continued exercise participation following the termination of the exercise program (McAuley, 1993). Four months following the termination of the exercise program self-efficacy was the only significant individual predictor of exercise behaviour, predicting 12.5% unique variance in continued exercise participation (McAuley, 1993). Similar results have been reported in studies evaluating exercise behaviour at 3 and 6 months (R^2=0.34, p<0.05) (Neupert, Lachman, & Whitbourne, 2009), 6 and 18 months (R^2= 0.27 and 0.25, p<0.05, respectively) (McAuley et al., 2003a), and 5 years (β=0.17, p<0.05) (McAuley et al., 2007) following program termination, suggesting that self-efficacy plays a pivotal role in long-term exercise adherence. Thus, it appears that the most crucial role of exercise self-efficacy in physical activity participation occurs when physical activity presents the greatest challenges, particularly during the initial stages of adoption and long-term maintenance. During the initial stages of the maintenance phase, satisfaction with the experiences afforded by a new behaviour has been found to be predictive of adherence to the behaviour (Hertel et al., 2008). When structured exercise programs are terminated, the onus of continuing exercise is completely on the individual. This involves planning, initiating, and maintaining an exercise behaviour as well as restarting when setbacks occur; therefore, long-term maintenance is a highly challenging task (Sniehotta et al., 2005). The points of saliency of self-efficacy in the exercise process are reflective of the social cognitive perspective that efficacy cognitions are most important in high-demand situations, while cognitive control systems tend to give way to lower control systems when task demands are less challenging (i.e. when beyond adoption and adaptation) (Bandura & Wood, 1989).

In a randomized control trial that compared an efficacy-based exercise program with an attention control exercise program in114 sedentary middle-aged adults, participants in the intervention group walked more frequently, for longer periods of time, and for greater distances than the control group ($p<0.05$) (McAuley et al., 1994). Those in the intervention group also demonstrated significantly greater attendance over the 5 months compared with the control group (67% vs. 55%, $p<0.05$). Considering the attrition rate in exercise programs is fairly high and that most participants withdraw before any health benefits are realized (approximately 50% in the first 6 months), it is encouraging to see that self-efficacy interventions may reduce participant attrition (McAuley et al., 1994).

Given that exercise self-efficacy appears to be a principal determinant of exercise behaviour, it is also targeted as an outcome in intervention studies (Allison & Keller, 2004; McAuley, Courneya, & Lettunich, 1991; McAuley et al., 1993; McAuley et al., 2003a). Even an acute bout of exercise can act as a mastery experience and enhance self-efficacy (McAuley et al., 1991; McAuley et al., 1993), while chronic exercise experiences produce even greater improvements (McAuley et al., 1993). Therefore, an important facet of enhancing exercise self-efficacy appears to be getting people to actually begin exercise. However, long-term follow-up studies have demonstrated a curvilinear function; during the intervention there are gains in self-efficacy but these have typically been followed by declines at 6 (McAuley et al., 1999) and at 9 months (McAuley et al., 1993) post-program follow-up. Interestingly, McAuley *et al.* (1993) found that following an acute bout of exercise at post-program follow-up, self-efficacy was restored to levels that were not statistically different from those at the end of the exercise program; highlighting the dynamic nature of efficacy cognitions. Further, in a later review McAuley *et al.* (2001) suggested that such an occurrence may indicate that self-monitoring of physical progress and conditioning can provide adequate feedback information to maintain efficacy at optimal levels.

Another major pathway by which self-efficacy may influence physical activity is through self-regulatory behaviour (Anderson, Worjcik, Winett, & Williams, 2006; Rovniak et al., 2002; Sniehotta et al., 2005). Bandura (1997) suggested that self-regulatory self-efficacy, or one's perceived capability to maintain physical activity in the face of challenges and setbacks, was crucial for success in maintaining regular exercise. Enhancing exercise self-efficacy can favourably change self-regulatory strategies. Self-efficacious individuals are more likely to engage in goal-setting, self-monitoring, planning, and problem solving; facilitating the incorporation of regular exercise successfully into daily life (Rovniak et al., 2002).

Further, in study which evaluated the aspects of an exercise program experience that influence self-efficacy, structural modeling analyses revealed that previous exercise experience, affect experienced during exercise, and exercise social support had significant direct effects on exercise self-efficacy (McAuley et al., 2003a). This has important implications for how researchers and practitioners structure self-efficacy-based exercise programs, maximize self-efficacy, and enhance adherence.

Exercise self-efficacy has also been associated with measures of physical function performance (7-meter walk, 8-Foot Up-Go, Stairs Up, and Stairs Down) and functional limitations (Function and Disability Instrument's advanced lower extremity function and basic lower extremity function). In 240 older women (mean age = 68.2 years), exercise-self efficacy was significantly associated with latent variables of functional performance (r=-0.58) and functional limitations (r=0.75) (McAuley et al., 2006).

2.3.1.2 Individuals with Chronic Diseases

The utility of self-efficacy for exercise adoption and maintenance has been applied to interventions for many chronic disease populations. The effects of self-efficacy for exercise have been well documented in the cardiac (Carlson et al., 2001; Sniehotta et al., 2005), chronic obstructive pulmonary disease (COPD) (Jeng et al., 2002), fibromyalgia (Culos-Reed & Brawley, 2000), osteoarthritis (Rejeski et al., 1998), multiple sclerosis (Ferrier, Dunlop, & Blanchard, 2010; Stroud, Minahan, & Sabapathy, 2009) and arthritic populations (Gecht, Connell, Sinacore, & Prohaska, 1996). Self-efficacy for exercise was a significant predictor of exercise behaviour in many of these symptomatic populations. In the cardiac population, exercise self-efficacy was the strongest predictor of physical activity (p=0.015); proving to be more reliable than measures of self-reported physical function and ratings of perceived exertion (Oka et al., 1996). Further, a 12-week self-efficacy intervention combined with regular cardiac rehabilitation was associated with a 134% ($p<0.001$) increase in 6-minute walk distance in a group of post-cardiac event older adults (n=28) (Allison & Keller, 2004). Baseline self-efficacy scores were moderately associated with self-reported physical activity (PASE) (r=0.62, p=0.01) and strongly correlated with mean distance walked (6-minute walk test) (r=0.84, p=0.01) (Allison & Keller, 2004).

In addition to task self-efficacy, recent studies in the cardiac population have also underscored the importance of barrier self-efficacy as both appear to be important target variables to develop during exercise programs. Millen and Bray (2008) found barrier self-efficacy to be the only significant predictor (R^2=0.11, p<0.05) of exercise behaviour 6-weeks following a cardiac rehabilitation program, suggesting that individuals who were more efficacious to overcome common barriers were more successful in transferring the activities learned during the rehabilitation program to home-based exercise. However, 12 weeks post-program, barrier self-efficacy ceased to be a significant predictor; rather, task-self-efficacy became the only significant predictor of exercise behaviour. Similarly, Blanchard, Rodgers, Courneya, Daub, and Black (2002) also found task, but not barrier, self-efficacy to be a significant predictor of exercise behaviour 6-10 weeks following a cardiac rehabilitation program. Therefore, for better long-term adherence it may be important to focus on fostering task-self efficacy during the later stages of an exercise program.

Among individuals with COPD, exercise self-efficacy was a significant predictor of mortality when compared to physiological variables of disease severity including forced expiratory volume in 1 second, arterial blood gas measurement of resting partial pressure of oxygen, and single-breath diffusing capacity (Kaplan et al., 1994). Exercise self-efficacy-based interventions have also been shown to enhance exercise self-efficacy while also eliciting subsequent improvements in health related quality of life (Lox & Freehill, 1999) and exercise tolerance (Allison & Keller, 2004; Lox & Freehill, 1999). Following a 12-week pulmonary rehabilitation program, COPD patients (n=40) showed a 14% (p<0.0001), 27% (p<0.0001), and 20% (p<0.0001) increase in 6-minute walk self-efficacy, 6-minute walk distance, and quality of life, respectively (Lox & Freehill, 1999). Increases in exercise tolerance were significantly associated with self-efficacy (r^2=0.078, p<0.01), which was significantly associated with quality of life (r^2= 0.054, p<0.05) (Lox & Freehill, 1999).

In light of the alarmingly low levels of physical activity in the ESRD population, it is important to understand factors that influence exercise participation in this population. Unfortunately, little research exists regarding factors that impede or facilitate activity among renal failure patients. There are two notable studies which have evaluated perceived barriers and motivators among HD patients. Goodman and Ballou (2004) reported that the most potent barriers to physical activity among HD patients (n=50) were lack of motivation, lack of interest, fear of falling, and lack of access to exercise facilities; each correlated negatively with exercise level. Enjoying how exercise feels and belief in one's ability to be physically active were the motivators reported to have the greatest influence on exercise levels (r=0.44 and r=0.40, $p<0.01$, respectively). More recently, the most common barriers to exercise participation among HD patients, from the perspective of patients (n=17), nurses (n=24), and family care providers (n=8), were health-related impairments, transportation, lack of time, and nurses' lack of encouragement to exercise (Kontos et al., 2007). Motivators to exercise included patient aspirations to exercise and their experienced improvements from previous exercise, as well as the incorporation of exercise into standard care practices (Kontos et al., 2007).

In the ESRD population, self-efficacy has only been examined with respect to self-management behaviours including self-care activities, medication regimes, fluid and dietary restrictions, communication, and partnership in care (Curtin et al., 2008; Tsay, 2003). Despite the numerous well-documented benefits of exercise for ESRD patients, it appears that exercise still is not recognized as a self-management health behaviour essential for enhanced survival and quality of life in this population. Further, even with an overwhelming amount of research supporting the important role self-efficacy plays in the adoption of and adherence to exercise in both the general and chronic disease populations, self-efficacy for exercise and its effects on physical activity levels have yet to be studied in the ESRD population.

Using a qualitative approach, a previous study in our lab evaluated HD patients' (n=7) perceptions of their physical, emotional, and social well-being after completing an 8-week intra-dialytic exercise program (Kolewaski et al., 2005). Participants reported enhanced perceptions of stamina and strength, which they felt improved their ability to perform activities of daily living. Particularly important was that participants reported having more energy and greater ability to tolerate desired activities for longer durations without getting tired, which in a clinical population that typically experiences low energy levels can be of vast significance. Specifically alluded to were enhanced perceptions of being able to maneuver stairs, go to the mall, go away for a weekend, work longer hours, and be active after dialysis treatments. Not surprisingly, exercising was found to not only enhance participants' sense of well-being, but also their perception of being able to personally influence their overall health. All participants expressed that performing intra-dialytic exercise provided them with a sense of accomplishment and improvement. One participant was quoted as saying "You are getting stronger and you are getting more energy, but also it is encouraging that you can do it, like, 'Yes, I can do this'." Further, Goodman and Ballou (2004) identified that "knowing the value of increased exercise" was a significant motivator to exercise among the ESRD population. Therefore, the positive changes in physiological and affective state that can accompany intra-dialytic exercise may facilitate the adoption of physical activity by increasing one's perceived capability to perform various activities and revealing the various health benefits and subsequent improvements in quality of life that are associated with an active lifestyle.

It is believed that a structured intra-dialytic exercise program will provide the opportunity for participants to experience mastery and vicarious experiences and to improve their physiological and affective states, effectively increasing self-efficacy for exercise. Therefore, the purpose of this pilot study was to a) investigate the effects of a low-intensity intra-dialytic exercise program on self-efficacy and continued physical activity in the HD population, and b) to determine the appropriateness of existing measurement tools and the proposed intervention for use in larger scale studies.

Chapter 3
Methods

3.1 Participant Recruitment

Participants were recruited from the Kingston General Hospital Satellite Hemodialysis Unit at the Providence Care, Mental Health Services site in Kingston, ON. To be eligible to participate in the study participants had to be 18 years of age or older, be fluent in English, be capable of lower limb activity, have no cognitive impairment, have been on dialysis for a minimum of 3 months, and have medical clearance by a nephrologist in order to participate in an exercise program.

The study and outcome measures were verbally explained to the patients and they were subsequently invited to participate in the study. Patients were informed that they would be matched with another participant based on age and gender and then randomly assigned to either a Control group or Exercise group. Those individuals who volunteered to participate were given a copy of the informed consent form and asked to sign it (Appendix A, Item 1). All procedures were approved by the Health Sciences Research Ethics Board at Queen's University (Appendix A, Item 2).

Initially, participants were recruited from the morning and evening dialysis sessions. Ten of 17 eligible patients agreed to participate. Early in the protocol, 2 participants in the Exercise group were unable to continue participation in the study (incarceration, medical issues) and had to withdraw, while a third in the Control group chose to discontinue (lack of interest). In response to poor initial recruitment and subsequent participant attrition, recruitment was extended to individuals in the Monday/Wednesday/Friday afternoon session. Only 1 of 6 eligible patients agreed to participate. Reasons for individuals declining included symptoms associated with comorbidities that were contraindicated with cycling such as joint pain and foot ulcers, already participating in regular structured physical activity, and not interested.

3.2 Outcome Measures

3.2.1 Participant Demographics and Medical Information

Age, gender, dialysis vintage (length of time on dialysis), Kt/V (measure of dialysis adequacy), primary diagnosis of renal failure, renal transplant status (i.e. whether or not they have had one previously), medications, and co-morbidities were recorded for each participant using a demographic information form (Appendix B, Item 1). Laboratory values for albumin, pre-albumin, protein catabolic rate (PCR), urea, creatinine, and hemoglobin were obtained from participants' clinic charts.

All blood work was performed monthly except for serum Kt/V and PCR, which are determined every 3 months. The laboratory values for Kt/V and PCR used in this study were obtained from tests performed closest to the given measurement time points (baseline, end of the 8-week intervention, and at 8 weeks post-intervention). It is recognized that a single point in time may not be a good indicator of overall status; however, if a value differed widely from previous measures, the abnormality was investigated so a more representative value could be obtained.

3.2.2 Self-Report Measures of Physical Activity and Physical Function

3.2.2.1. The Human Activity Profile (HAP)

The HAP is a self-report questionnaire used to assess physical activity and functional capacity. It consists of 94-items listed in ascending order according to energy requirements; activity energy costs range from 1 to 10 metabolic equivalents (METS) (Appendix B, Item 2) (Fix & Daughton, 1988). For each item in the scale, individuals indicate whether they, (1) are still doing this activity, (2) engaged in this activity in the past, but have now stopped doing this activity, or (3) never did this activity. Two scores are determined; the Maximal Activity Score (MAS) and the Adjusted Activity Score (AAS). The MAS is the highest item number an individual indicates he/she is still doing and represents the highest energy requiring activity the person is still performing. The AAS is the MAS minus the total number of activities below the MAS that the respondent has indicated that he/she has stopped doing. The AAS is considered to be a measure of usual physical activity since it reflects the range of activities an individual is still doing (Davidson & de Morton, 2007). Additionally, because it provides an indication of how an individual is functioning within their maximal energy capacity, the AAS may also be viewed as an indicator of functional ability. The HAP has been shown to have high test-retest reliability, with correlation coefficients ranging from 0.76 to 0.97 for the MAS and 0.79 to 0.97 for the AAS (Davidson & de Morton, 2007). Validity of the HAP has been demonstrated by good correlations with various self-report and objective measures of physical activity and physical function in people with chronic diseases, including those with renal failure (Davidson & de Morton, 2007; Johansen et al., 2001b). Specifically, in individuals with ESRD, the HAP correlated well with objective measures of physical activity such as accelerometry (r=0.78) (Johansen et al., 2001b). Further, good correlations were also found with measures of physical function including the SF-36 physical function score (MAS r=0.68, AAS r=0.82) and gait speed (MAS r=0.72 and AAS r=0.72) (Johansen et al., 2001b). Johansen *et al.* (2001b) reported that of 4 self-report measures of physical activity and/or physical function (the Stanford 7-day Physical Activity Recall, the Physical Activity Scale for the Elderly, and the Short Form (SF) 36-item questionnaire, the HAP), the HAP demonstrated the best test-retest reliability and the greatest correlation with accelerometry in individuals on maintenance hemodialysis (Johansen et al., 2001b).

3.2.2.2. Physical Activity Diary

A 7-day physical activity diary (Appendix B, Item 3) was designed by the investigators to assess weekly levels of physical activity. Participants were asked to report their daily physical activity including the duration of each activity and the accompanying level of perceived exertion (i.e. easy, moderate, and vigorous). The weekly physical activities were converted to kcal using METs. The updated Compendium of Physical Activities was used to assign a MET value to each activity based on the description and level of perceived exertion reported (Ainsworth et al., 2000). The energy cost (kcal) of an activity was then estimated by multiplying the assigned activity MET value by the activity duration and the participant's dry body weight (kg). A weekly estimate of a participant's physical activity energy expenditure was calculated by summing the estimated energy expenditure of each activity reported in that week.

Studies have shown good test-retest reliability for estimates of energy expenditure using an activity diary. Interclass correlation coefficients ranged from r=0.80 to 0.96 in healthy subjects (Baranowski et al., 1999; Bouchard et al., 1983) and patients recovering from coronary artery bypass graft surgery (Hertzog et al., 2007). The validity of physical activity diaries has been demonstrated by the comparison of estimated kcal values with reference measures of energy expenditure determined by doubly labeled water (Bratteby, Sandhagen, Fan, & Samuelson, 1997; Riumallo, Schoeller, Barrera, Gattas, & Uauy, 1989), direct and indirect calorimetry (Brun, Webb, de Benoist, & Blackwell, 1985; Edholm, Fletcher, Widdowson, & McCance, 2007; Geissler, Dzumbira, & Noor, 1986) and the energy intake/balance technique (Borel, Riley, & Snook, 1984; Kalkwarf, Haas, Belko, Roach, & Roe, 1989). Good correlations have been demonstrated between activity diaries and doubly labeled water (n=6), (r=0.72) (Riumallo et al., 1989) and the energy balance technique (n=12), (r= 0.90, for males, r=0.53, for females) (Borel et al., 1984). The mean estimates of daily energy expenditure from activity diaries have been reported to be within 1% and 4% of reference energy expenditures as determined by respirometry (Geissler et al., 1986) and the energy balance method (Kalkwarf et al., 1989), respectively.

The Compendium of Physical Activities was developed to provide a comprehensive list of published energy costs that would, “facilitate the coding of physical activities obtained from physical activity records, logs, and surveys and to promote comparability of coding across studies” (Ainsworth et al., 2000). It is a widely accepted extrapolation tool used among physical activity specialists in the exercise science and public health field (Ainsworth et al., 2000; Neilson, Robson, Friedenreich, & Csizmadi, 2008) and has been used in national and international physical activity surveys (Ainsworth et al., 2000). The MET values in the compendium are averages based on published lists and selected unpublished data of laboratory measures.

Studies have shown that published values provide accurate estimates of energy expenditure for a population (Acheson, Campbell, Edholm, Miller, & Stock, 1980; Borel et al., 1984; Kalkwarf et al., 1989). The accuracy of published energy cost values has been demonstrated by a lack of significant difference between the energy cost of individual activities measured in the laboratory and values previously published in the literature (Kalkwarf et al., 1989) and a lack of significant difference between estimations of energy expenditure determined with published energy costs and values of energy expenditure measured in the laboratory (Acheson et al., 1980; Borel et al., 1984; Kalkwarf et al., 1989). However, the authors of the Compendium state that the activity energy cost values are not intended for individuals with metabolic inefficiencies. Individuals with ESRD, in general, are thought to have metabolic impairments, suggesting that the use of activity energy cost values from the Compendium may not be appropriate for estimating energy expenditure in this population. On the other hand, Monteon, Laidlaw, Shaib, and Kopple (1986) found that for a given physical activity, energy expenditure in HD patients was not different from healthy individuals. There were no significant differences between healthy individuals (n=12) and hemodialysis patients (n=16) in energy expenditures measured by indirect calorimetry at rest, during exercise, or at the postprandial state. Further, during exercise, energy expenditure was directly correlated with work performed and the regression equation was similar to that in healthy individuals. Therefore, the activity energy cost values in the Compendium appear to be appropriate for this population.

3.2.3 Self-Efficacy

3.2.3.1. Exercise Self-Efficacy Scale (ESES)

The Spinal Cord Injury (SCI) ESES is a 10-item self-report measure that was designed to assess levels of exercise self-efficacy among individuals with SCI (Appendix B, Item 4) (Kroll, Kehn, Ho, & Groah, 2007). Using a 4-point Likert scale, with “1” being “not true at all” and “4” being “always true”, respondents indicate how confident they are performing regular physical activity and exercise in the presence of various barriers. A total score of 40 is calculated to provide an indication of the individual’s overall self-efficacy for physical activity and exercise. The SCI ESES has shown good reliability and a high degree of internal consistency among items; Cronbach’s alpha value was 0.93 (Kroll et al., 2007). Good construct validity was demonstrated by Principal Component Factor Analysis which showed that all items loaded on only a single factor, “SCI Exercise Self-Efficacy”, and that there was only a modest correlation between ESES and a General Self-Efficacy questionnaire (Spearman $r=0.36$, $p<0.05$ $n=53$) (Kroll et al., 2007).

Due to the nature of kidney disease, HD patients experience many physical symptoms that make them hesitant to participate in physical activity. A pervious study in our lab explored the perceptions’ of HD patients regarding their physical, emotional, and social well-being after participating in an 8-week low-intensity intra-dialytic cycling program. The results revealed that following the exercise program, participants had enhanced confidence in their ability to perform activities of daily living (e.g. walking up/down stairs, not fatiguing as easily during social/recreation activities) (Kolewaski et al., 2005). Further, it appeared that the perceived benefits of physical activity acted as a catalyst toward incorporating physical activity into daily life. Therefore, by participating in an exercise program, it was hoped that the participants in this study would experience changes in their physiological and affective states that would enhance their confidence to overcome personal and environmental barriers and engage in more daily activity. There is no specific physical activity self-efficacy scale available for the ESRD population, therefore the SCI ESES was chosen for the current study because a) the items in the scale were not specific to the SCI population, in fact the items were selected from existing self-efficacy scales used in the general population (the General Perceived Self-Efficacy Scale (Jerusalem & Schwarzer, 1992), McAuley's Exercise Self-Efficacy Scale for the Elderly, and Exercise benefits/barriers scale (Sechrist, Walker, & Pender, 1987) and b) the items addressed issues affecting participation in physical activity and exercise that had been previously identified in studies which investigated barriers and motivators to exercise among individuals with ESRD (example fatigue, safety concerns, access to facilities) (Goodman & Ballou, 2004; Kolewaski et al., 2005; Kontos et al., 2007). Other scales were reviewed, many of which included questions that generally were not suitable for the ESRD population. For example, Bandura's ESES assesses how confident an individual is performing exercise during and after vacation (Bandura, 1997). However, due to the large financial and administrative burden associated with arranging dialysis treatment while travelling, many hemodialysis patients do not travel regularly. Further, many exercise self-efficacy scales were specific and assessed one's confidence to perform a particular exercise behaviour (e.g. aerobic and resistance training); however, we were not as interested in increasing participation in structured exercise as we were in increasing participation in general daily physical activity. Since the ESES primarily assessed one's confidence to be physically active in the face of relevant barriers, we felt that it was appropriate for this study.

3.2.3.2. Chronic Disease Self-Efficacy Scale (CDSES)

The CDSES is a 33-item questionnaire assessing the overall self-efficacy of chronic disease populations to self-manage their disease (Appendix B, Item 5) (Lorig, Stewart, & Ritter, 1996). Individuals identify their confidence to regularly complete the task outlined in each item on a 10-point Likert scale, with 1" being "not confident at all", and "10" being "totally confident". A total score is determined by calculating the mean score for all items in the scale with a maximum score being 10. There are ten sub-scales that can be used to measure an individual's self-efficacy to Exercise Regularly, Get Information About the Disease, Obtain Help from Community, Family, and Friends, Communicate with their Physician, Manage the Disease in General, Do Chores, Participate in Social and Recreational Activities, Manage Symptoms, Manage their Shortness of Breath, and Control/ Manage depression. Each scale score is the mean of the related items in each scale. Due to the specific nature of self-efficacy, the scales of particular interest were the Exercise Regularly Scale, Do Chores, and Participate in Social and Recreational Activities since gains in self-efficacy during the exercise intervention were expected to transfer to these behaviours. Although changes were not expected in the other scales, enhanced feelings of wellness and self-control have been reported following an intra-dialytic exercise program (Kolewaski et al., 2005). Therefore, the use of this scale would enable us to determine if other self-management behaviours were affected by the intra-dialytic exercise intervention.

The CDSES has shown to have good reliability. Internal consistency coefficients for the sub-scales ranged from 0.77 to 0.92 and the test-retest reliability coefficients ranged from 0.72 to 0.89 in individuals with one of four major chronic diseases: heart disease, lung disease, stroke or arthritis. Good construct validity has been demonstrated; multi-trait scaling analysis showed that all item-scale correlations exceeded 0.50, indicating item convergence, while items were correlating at least one standard error higher with their own scale than other constructs, indicating discriminant validity (Lorig et al., 1996).

3.3 Protocol

The study covered an 18-week period, during which time all participants completed 7-day physical activity diaries (Figure 1). Outcome measures were completed at baseline (PRE), the end of the 8-week intervention period (POST), and 8-weeks following the intervention (FUP).

Two weeks prior to the start of the intervention, all participants completed the weekly physical activity diaries so that baseline physical activity levels could be established. During the 8-week intervention period, the Exercise group completed an 8-week, supervised, low-intensity intra-dialytic exercise program (no more than 4 on a 10-point rating of perceived exertion scale). Participants exercised 3 times a week during the first 30 minutes of each of the first two hours of dialysis using a cycle ergometer (Rehab Trainer) at a self-selected intensity and pace. Exercise bouts took place within the first two hours of the dialysis session to ensure cardiovascular stability (Moore, Painter, Brinker, Stray-Gundersen, & Mitchell, 1998; Parsons et al., 2004). Initially, 2 of 4 participants in the Exercise group were not able to complete 30 minutes of continuous exercise and cycled for shorter times, gradually increasing toward 30 minutes of exercise. Blood pressure and heart rate were monitored prior to, during, and following exercise. Participants were asked to rate their level of perceived exertion on a 10-point scale in order to determine the relative intensity of exercise (Borg, 1998). Participants in the Control group continued with their regular dialysis treatments and were asked to maintain usual levels of physical activity. In the 8-week post-intervention period, all participants had the option to exercise. No participant was given encouragement to exercise during dialysis; however all participants were informed that investigators and exercise equipment were available if they wished to exercise.

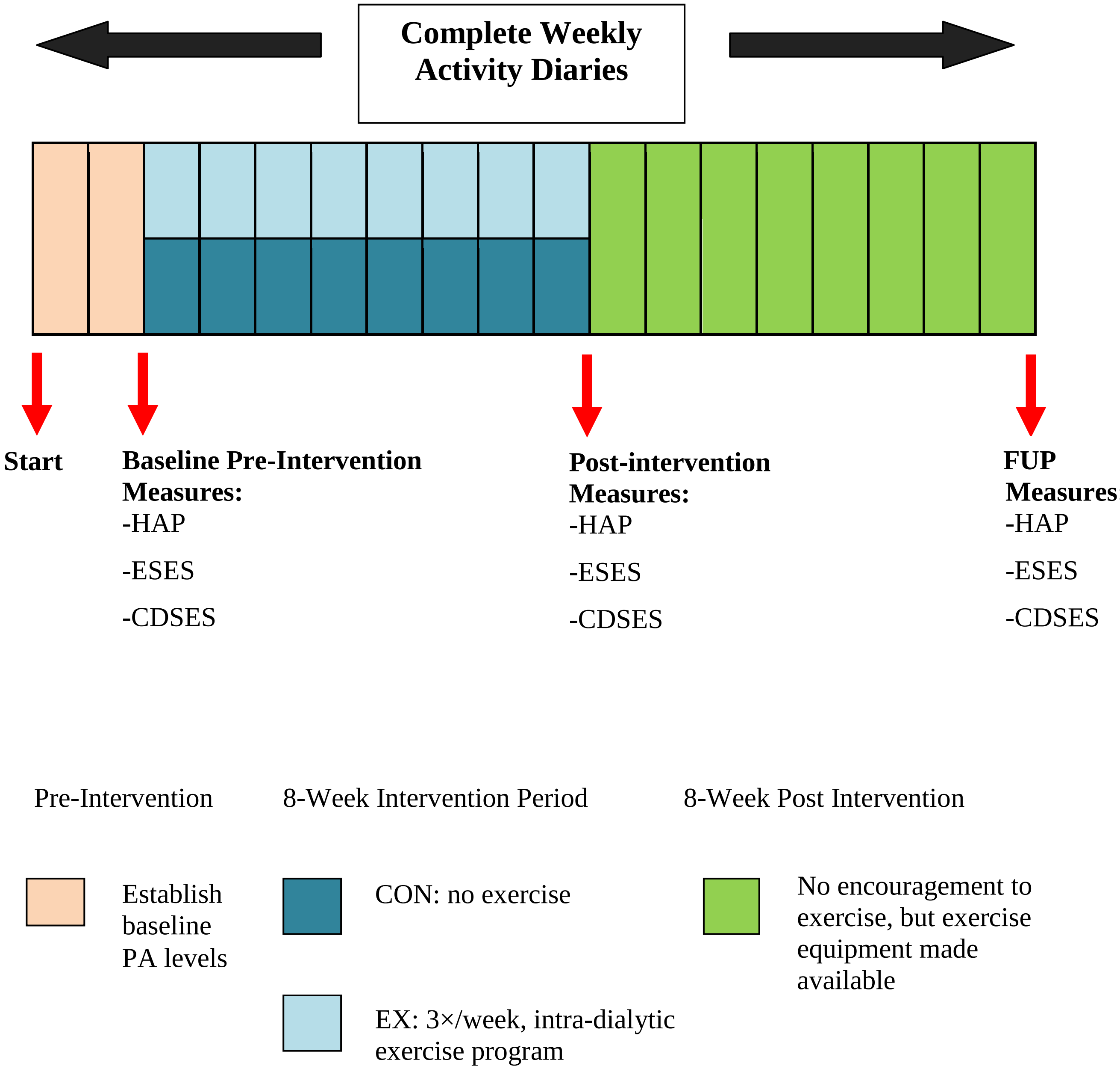


Figure 1. Experimental Design. Prospective randomized control design. Each block represents one week. PA, physical activity; CON, Control group; EX, Exercise group; FUP, follow-up; HAP, Human Activity Profile; ESES, Exercise Self-Efficacy Scale; CDSES, Chronic Disease Self-Efficacy Scale.

3.4 Data Analysis

All data are reported as means ±standard deviation (SD). Significant differences in outcome measures within and between groups at PRE, POST, and FUP were determined using a two-way repeated measures Analysis of Variance (ANOVA) (Sigma Stat 3.5, Systat Software Inc.), with a Holm-Sidak post-hoc analysis. The large discrepancy in MAS and AAS values between the Exercise and Control group prompted an investigation for potential contributing variables. Although not statistically different, the Exercise group tended, on average, to be younger and to have higher serum albumin concentrations than the Control group. Therefore, to determine whether serum albumin and age influenced the mean scores ± standard deviations (SD) of the HAP, ESES, and CDSES, particularly the total score and the scores for the Exercise Regularly, Do Chores, and Social and Recreational Activities sub-scales, an Analysis of Co-Variance (ANCOVA) was performed using IBM SPSS Statistics 18 with a Bonferonni post-hoc analysis. Significance was accepted at $p<0.05$. Participant adherence rates to the exercise intervention were calculated by dividing the number of exercise sessions completed by the total number of possible exercise sessions. Adherence rates were calculated for the Exercise group during the intervention period and for the Exercise and Control group during the follow-up period.

It is commonly argued that non-parametric tests should be employed when using nominal or ordinal data since they are more likely to deviate unacceptably far from normality than would a population of interval or ratio data (Portney & Watkins, 2009). While the HAP uses an interval scale, both the CDSES and ESES are ordinal scales and, classically, would be thought best analyzed using a non-parametric test. However, “parametric tests are generally considered robust enough to withstand even major violations of the assumptions associated with parametric testing without seriously affecting the validity of statistical outcomes, including their use with ordinal data" (Portney & Watkins, 2009, p.429). Additionally, according to Zar (1999, p. 146) "there is nothing in the theoretical basis of parametric hypothesis testing that requires interval or ratio data."Therefore, parametric tests were used unless the data failed to meet the assumptions of normality, in which case a non-parametric test was employed.

Finally, although there were low participant numbers, it was necessary to use parametric analysis so that the potential average change and variability in each outcome measure could be determined and a power analysis could be performed to estimate the number of participants that would be required in a larger scale study.

Chapter 4

Results

4.1 Demographic Characteristics

The demographic characteristics of the participants are listed in Table 1. Eight participants completed the study; 4 were randomly assigned to each group. Participants were middle aged and had few co-morbidities. Participants in both groups were on a large number of medications (9-13), including regular regimens of phosphate binders, erythropoietin, and various vitamin and mineral supplements. Primary diagnosis of renal failure included glomerulonephritis (n=3), reflex nephropathy (n=1), cancer (n=1), cardiovascular disease (n=1), hypertension/Type II diabetes (n=1), and Haemolytic Uremic Syndrome (n=1). Dialysis vintage in the Exercise group ranged from 33-264 months and from 14-372 months in the Control group. It is not surprising that 3 out of 4 participants in each group were on some form of cardiovascular medication considering the numerous cardiovascular complications associated with ESRD. While there were no statistically significant differences between groups for any demographic characteristic, the Control group, on average, tended to be slightly older and have more co-morbidities than the Exercise group. Participants were matched as best as possible for age and gender, however some pairs were not exactly the same age. Further, 3 participants withdrew from the study, 2 from the Exercise group and 1from the Control group, which resulted in the Control group having the two most elderly participants. The inability to detect group differences was most likely due to low statistical power associated with the small sample size.

Table 1. Participant Demographic Information

	Exercise Group (n = 4)	Control Group (n = 4)
Gender		
Male	2	3
Female	2	1
Age (yrs)	44.5±18.0	56.0±23.1
Dialysis Vintage (months)	144.0±125.1 (33-264)	125.5±165.7 (14-372)
Number of Co-Morbidities	1.3±1.0	2.5±2.4
Renal Transplant Status:		
No	2	3
Yes	2	1
Number of Medications	9.3±1.0	13.0±5.8
Type of Medication:		
CV	3	3
Cholesterol	0	2
PO_4^{-3} Binders	4	4
K^+ Binders	0	2
Vitamin/Mineral Supplements	4	4
EPO	4	4
GI	2	1
Other	3	4

Values are means ± standard deviations. Gender, renal transplant status, and type of medication are reported as the number of participants in each category. CV; cardiovascular; PO_4^{-3}, phosphate; K^+, potassium; EPO, erythropoietin; GI, gastrointestinal.

4.2 Adherence Rates

The mean values ± standard deviation for the adherence rates of the Exercise group (n=4) to the exercise program was 100±0% and 93±26% during the intervention and follow-up period, respectively. The adherence rate for the participant in the Control group during the follow-up period was 73%. The weekly adherence rate (number of exercise sessions completed divided by total number of possible exercise sessions) and exercise duration for each participant is shown in Appendix C.

4.3 Measures of Clinical Markers

The mean values ± standard deviations for the laboratory clinical measures are listed in Table 2. Participant levels of serum urea and creatinine were representative of individuals in stage 5 renal failure (Life Options, 2010). The values for Kt/V (online) exceeded the target dose of 1.4 recommended in KDOQI clinical practice guidelines (National Kidney Foundation, 2006). In both groups, hemoglobin was maintained in the target range of 110-112 g/L outlined by KDOQI guidelines (KDOQI, 2007). Even though the normal range for healthy individuals is higher (123-157, females, 140-174, males) (The Medical Council of Canada, 2010), hemoglobin levels greater than 113 g/L are not necessarily beneficial in the ESRD population and have been associated with adverse cardiovascular events (KDOQI, 2007). The values of serum albumin, pre-albumin, and PCR were within recommended ranges of ≥40 g/L, ≥ 0.30 g/L (Kopple, 2001), and 1.0-1.4 g/day, respectively (Shinaberger, Kilpatrick, Regidor, McAllister, & Greenland, 2006). Values for PCR are provided at PRE and FUP. POST values were unavailable because PCR is measured only once every three months. There were no significant differences in laboratory values between or within groups at any point in the study. However, levels of serum albumin tended to be higher in the Exercise than in the Control group at PRE, POST, and FUP.

Table 2. Clinical Measures of Kidney Function, Dialysis Adequacy, Hemoglobin, and Nutritional Status

	Exercise Group (n = 4)	Control Group (n = 4)
Kidney Function		
Urea (mmol/L)		
PRE	19.5±1.5	19.9±6.8
POST	22.6±2.8	19.1±3.7
FUP	19.1±3.1	22.3±7.2
Creatinine (µmol/L)		
PRE	821±365	846±194
POST	876±415	908±153
FUP	840±356	958±198
Dialysis Adequacy		
Kt/V (online)		
PRE	1.8± 0.1	1.7±0.3
POST	1.8±0.1	1.7±0.1
FUP	1.9±0.2	1.6±0.3
Hemoglobin (g/L)		
PRE	120.3±3.1	115.3±4.9
POST	114.8±6.8	115.8±12.9
FUP	110.0±4.2	116.5±5.7
Nutritional Markers		
Pre-Albumin (g/L)		
PRE	0.3±0.1	0.4±0.0
POST	0.3±0.1	0.3±0.0
FUP	0.3±0.1	0.4±0.0
Albumin (g/L)		
PRE	38.3±2.1	36.8±4.5
POST	38.8±2.2	35.0±1.8
FUP	38.5±1.3	34.5±3.8
PCR (g/kg/day)		
PRE	1.5±0.3	1.6±0.3
POST	na	na
FUP	1.7±0.4	2.0±0.8

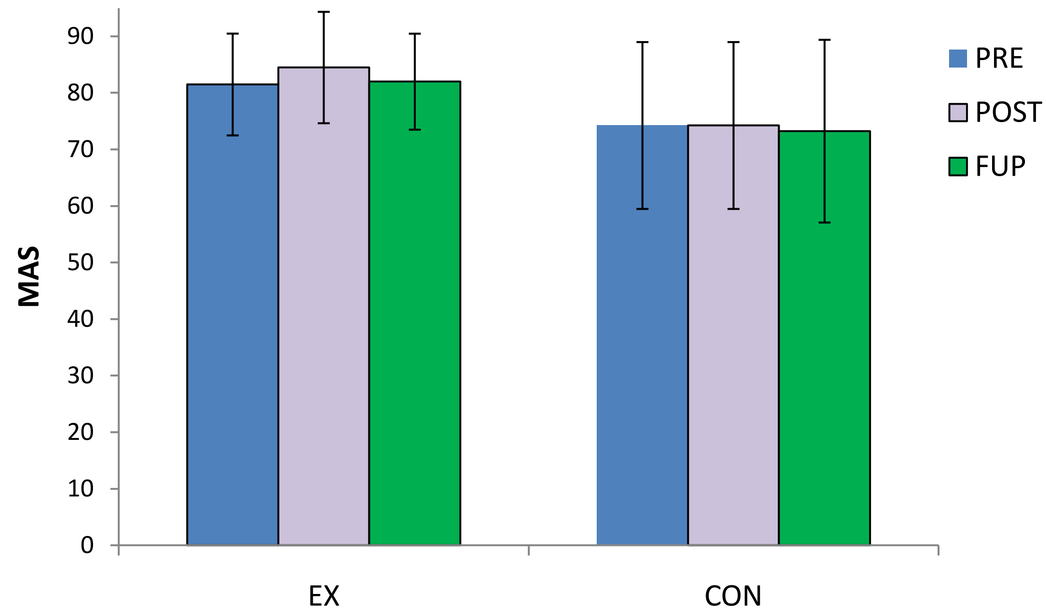
Values are means ± standard deviations. PRE, prior to intervention; POST, end of 8-week intervention; FUP, 8-weeks post-intervention; PCR. Protein catabolic rate.

4.4 Outcome Measures

The mean values ± standard deviations for the MAS and AAS are shown in Panels A and B respectively in Figure 2. There were no significant differences between or within groups at PRE, POST, or FUP. However, the Exercise group tended to have higher MAS and AAS values throughout the study. Both groups reported unusually high levels of physical activity and functional ability. Because participants are required to volunteer, it may be that those who were already physically active and confident in their ability to exercise were the ones who agreed to participate, leading to a sample of highly active participants. Values for the MAS and AAS previously reported in the ESRD population have been 70.4±15.0 and 55.4±21.5 (Johansen et al., 2001b) and 55.2±14.9 and 43.6±19.1, respectively (Fix & Daughton, 1988). The mean value of the PRE, POST, and FUP scores was 82.7±8.4 (MAS) and 82.5±8.5 (AAS) in the Exercise group and 73.9±13.8 (MAS) and 67.4±19.5 (AAS) in the Control group; more closely resembling the normative values for healthy individuals aged 20-79 years of 85.3±7.9 (MAS) and 83.2±7.8 (AAS) (Fix & Daughton, 1988). The failure to find significant changes between or within groups may have been due to a ceiling effect in combination with low statistical power as a result of the small sample size.

A power analysis was performed to estimate the sample size required to have a statistical power of 0.8 given a minimum detectable change of 5 points on the HAP with a standard deviation of 12. A sample size of 178 (89 in each group), 184 (92 in each group), or 48 would be required for an analysis of variance (ANOVA), a t-test, or a paired t-test, respectively. If the target population was limited to those with low self-efficacy and physical activity levels, it is envisioned that greater changes in theses outcomes would occur with an exercise intervention. Therefore, given a minimum detectable change of 10 points on the HAP, and a standard deviation

A.



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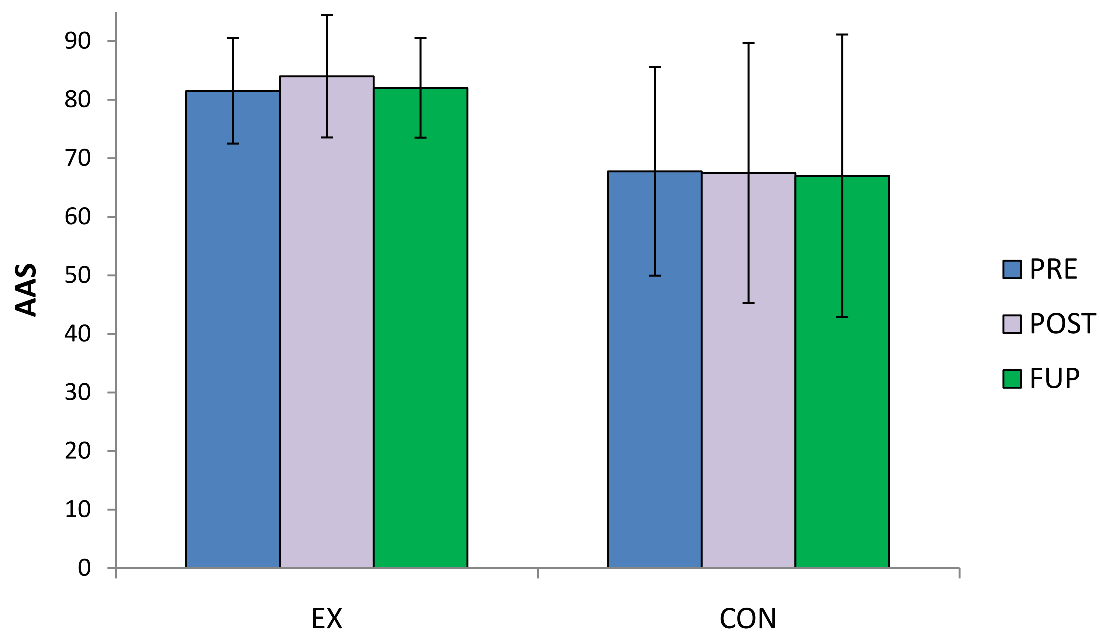


Figure 2. Values are means ± standard deviations for the Maximal Activity Score (MAS) (Panel A) and the Adjusted Activity Score (AAS) (Panel B) of the Human Activity Profile for the Exercise (EX) and Control (CON) group. PRE, prior to intervention; POST, end of 8-week intervention; FUP, 8-weeks post-intervention.

of 15, 72 (36 in each group) and 114 (57 in each group) participants would be required to perform an ANOVA and t-test, respectively, with a statistical power of 0.8.

The mean values ±standard deviations for the estimated physical activity energy expenditures for the Exercise and Control groups are listed in Panel A of Table 3. There were no significant differences between or within groups over the course of the study. The standard deviations indicate a large variation in estimated energy expenditure.

The mean compliance for individuals who regularly completed the weekly physical activity diaries was fairly high; 85% in the Exercise group (≈15/18 diaries received) and 96% in the Control group (≈17/18 diaries received). However, 1 participant in each group failed to complete the activity diary on a regular basis and thus only 3 data sets in each group could be used to determine the average weekly estimates of activity energy expenditure. The literature unanimously reports that activity diaries are only accurate indices of physical activity levels when used with populations and that the variation in estimates of energy expenditure are too large for activity diaries to be a reliable measure in individuals (Acheson et al., 1980; Borel et al., 1984; Bratteby et al., 1997; Geissler et al., 1986; Kalkwarf et al., 1989). Consequently, the small number of data sets compromised the validity of this tool in this study.

The reporting of activity was inconsistent from week to week, bringing into question the reliability of the data. Some weekly diaries provided precise accounts of daily activity while other weeks participants provided only limited details regarding their activity behaviour. For such reasons, the information from the physical activity diaries were used in a descriptive capacity rather than a quantitative one.

Table 3. Estimated Weekly Mean Physical Activity Energy Expenditures for Each Group and for Individuals

A.

	Exercise Group (*n*=3)	Control Group (*n*=3)
Weekly Physical Activity Energy Expenditure (kcal)		
PRE	5651.0±1964.9	5252.9±3178.8
POST	6844.0±2731.3	5050.3±3589.9
FUP	5865.7±3203.5	5130.6±3599.1

B.

EXERCISE GROUP				CONTROL GROUP			
	PRE	POST	FUP		PRE	POST	FUP
E1	3803±2264	3696±480	2544±825	C1	1611±103	931±276	978±174
E2	5435 (only one week, no SD)	8252±1204	8936±2658	C2	6680±781	6707±1054	7054±813
E3	7715±269	8584±859	6117±1081	C3	7468 (only one week, no SD)	7513±897	7360±1110
E4	na	na	na	C4	na	na	na

Values are means ± standard deviations for the estimated weekly physical activity energy expenditure for the Exercise and Control group (Panel A) and each participant (Panel B). The numbers in Panel B correspond to a participant in the group. PRE, two-week period prior to the start of the intervention; POST, period from week 1-8; FUP, period from week 9-16.

The most common type of physical activity reported was household/yard work; all participants who completed the physical diaries reported performing household or yard activities regularly. Not surprisingly, individuals tended to engage in greater levels of physical activity on dialysis days or before dialysis compared to post-dialysis. All 4 participants in the Exercise group chose to continue exercising after the 8-week intervention and 3 of the 4 participants in the Control group chose to initiate exercise in the post-intervention period. However, 2 participants in the Control group had to discontinue the exercise. One participant had difficulty maintaining a safe fistula venous pressure while exercising. Due to a short stature, this person had to grip the armrest of the chair to prevent moving too far back from the pedals which increased the fistula venous pressure beyond a safe limit. The other participant had a history of hyperparathyroidism (elevated parathyroid hormone) and experienced joint pain and discomfort during and after cycling.

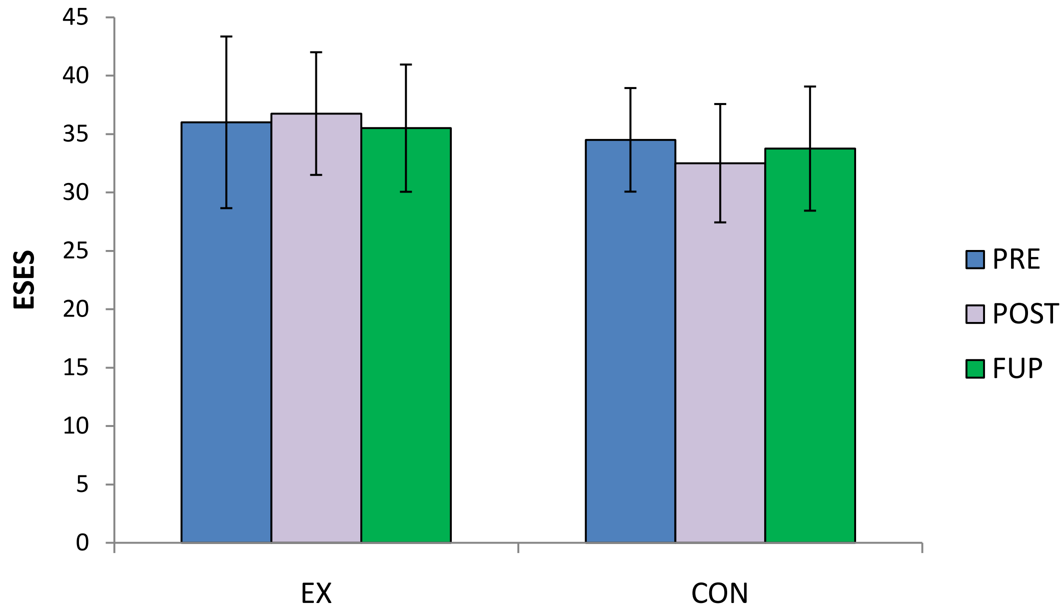
The mean values ± standard deviations for individual estimated weekly energy expenditures are listed in Panel B of Table 3 to provide greater information about the activity level of specific participants. However, the quantitative data from the activity diaries somewhat misrepresent the activity behaviour of the participants. In the Exercise group, it would appear that participant E3 had the greatest activity level. However, qualitative data from the diaries (i.e. recorded activity descriptions) suggests that participant E3 had a relatively inactive lifestyle. The vast majority of activities reported by participant E3 were light intensity (1-2.9 METS) activities of daily living. The greatest energy requiring activity reported regularly was cleaning (≈3 METS). The discrepancy between energy expenditure estimates and recorded activity patterns is due to the level of diligence exercised by the participant when recording daily activities and the types of activities being recorded. Participant E3 tended to primarily record activities of daily living such as occupational work, household work, and shopping. Activities of daily living, when accumulated over a day, result in a large number of activities reported and subsequent long durations of physical activity participation. As a result, the energy expenditure estimates reflected a relatively active lifestyle compared to individuals who recorded more vigorous, but less frequent and shorter duration activities. Such was the case with E1 and E2 who had lower estimated mean energy expenditures than E3, yet they engaged regularly in moderate to vigorous levels of physical activity (4-10 METS). Participant E1 participated in martial arts classes and calisthenic exercise 3 times a week while participant E2 engaged in many physically demanding leisure time activities including golf, tennis, canoeing, skating, skiing, and tobogganing in addition to regular thrice weekly vigorous resistance and cardiorespiratory training. Both E1 and E2 tended to report few low energy cost activities, or activities of daily living; reporting mainly their participation in structured physical activity, or higher energy cost activities. As a result, estimated activity energy expenditures were less than those of E3, giving the impression of lower physical activity levels.

Similar trends occurred in the Control group. It would appear, based on estimated activity energy expenditures, that participant C3 had the highest activity levels. However, according to the descriptive data in the diaries participant C3 did not engage in any activity beyond those of basic daily living. The greatest energy requiring activity completed regularly by participant C3 was house cleaning (≈3 METS). Similar to the Exercise group, this discrepancy between recorded physical activity behaviours and estimated energy expenditures was a result of zealous activity reporting on behalf of participant C3 relative to the other participants in the Control group and the types of activities that were recorded. Participant C3 recorded every activity performed from the morning until bed time, including self-care activities, light housework, shopping, and social events. On the other hand, participants C1 and C2 tended to report fewer activities of daily living; recording more conventional forms of physical activity such as walking, exercise, and manual work. Again, more vigorous activities tend to be performed less frequently and are of shorter duration than spontaneous, light-intensity, activities of daily living. Consequently, participants C1 and C2 had lower estimated energy expenditures than C3 despite participation in regular exercise for physical fitness. Participant C1 attended yogalates (yoga combined with pilates) exercise classes once a week and regularly performed moderate to vigorous intensity (4-6 METS) household and yard work/maintenance. Participant C3 did vigorous intensity (6-8 METS) resistance and calisthenic exercise three times a week in addition to various social and recreational activities including, playing the drums in a band.

The mean values ± standard deviations for the ESES and CDSES are shown in Panels A and B, respectively, in Figure 3. There were no significant differences between or within groups at PRE, POST, or FUP. Both groups reported relatively high levels of self-efficacy on both scales; the scores represented, on average, 87% of the total score of the ESES and CDSES. Previous investigations in our laboratory have shown that the mean score for the ESES and CDSES in 132 ESRD patients from Kingston General Hospital renal units was 27.6±7.7 and 6.9±1.8, respectively (Kack, Parsons, Toffelmire, & King-VanVlack, 2010). The 8 participants in this study represent a subset of these 132 patients. The relatively high scores at pre-intervention suggest that the participants already had a high level of self-efficacy for exercise and disease management. Therefore, in addition to low statistical power resulting from the small sample size, a ceiling effect may also have contributed to the lack of significant improvements between or within groups.

A power analysis was performed to estimate the sample size required to have a statistical power of 0.8 given a 10% change in the score of the ESES (4 points), and a standard deviation of 7. Sample sizes of 118 (59 in each group), 100 (50 in each group), or 27 would be required for an ANOVA, a t-test, or a paired-t-test, respectively. For the CDSES, with a 10% change in

A.



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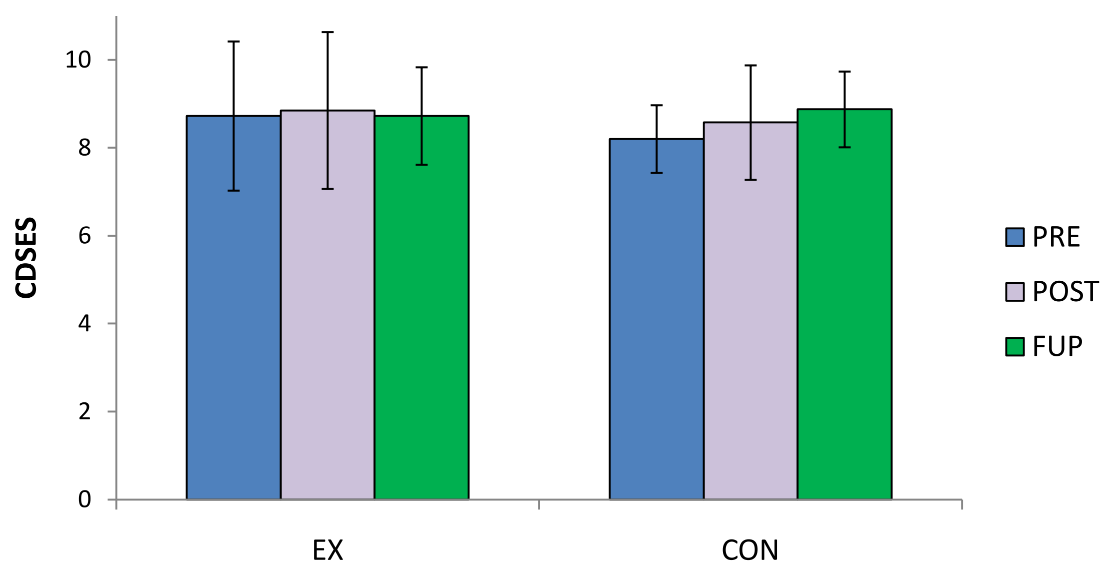

Figure 3. Values are means ± standard deviations for the scores of the Exercise Self-Efficacy Scale (ESES) (Panel A) and Chronic Disease Self-Efficacy Scale (CDSES) (Panel B) for the Exercise (EX) and Control (CON) groups. PRE, prior to intervention; POST, end of 8-week intervention; FUP, 8-weeks post-intervention.

score (1 point) and a standard deviation of 1.5, sample sizes of 126 (63 in each group), 74 (37 in each group), or 24 would be required for an ANOVA, a t-test, or a paired t-test, respectively.

The mean values ± standard deviations for the 10 sub-scales of the CDSES are listed in Table 4. Participants reported relatively high self-efficacy scores in all sub-scales ranging from 8.3-9.8 in the Exercise group and 7.0-10.0 in the Control group. There were no significant differences between or within groups except for a significantly greater level of confidence obtain help from the community, family, and friends at FUP relative to the beginning of the intervention in the Control group.

4.5 Analysis of Co-Variance (ANCOVA)

Even though no significant differences in demographic characteristics existed between groups, there was a noticeable difference of 12 years in age and 3.1 g/L in serum albumin levels between the groups. To determine if age or serum albumin may have influenced the results, an ANCOVA was performed for each outcome measure to correct for age alone, albumin alone, and both combined. The mean values ± standard errors for the MAS and AAS adjusted for age, albumin, and age and albumin are listed in Tables 5 and 6 respectively. The discrepancy in MAS and AAS scores between the Exercise and Control group at PRE, POST and FUP tended to be reduced following correction for age and albumin. Age was significantly associated with the MAS values (F (1, 23)=7.088, p=0.016,), while serum albumin was not (F (1, 23)=4.348, p=0.052). The AAS values were significantly related to both age (F (1, 23)=6.55, p=0.02) and serum albumin (F (1, 23)=6.71, p=0.019). Despite the significant associations between the covariates (age and albumin) and the MAS and AAS values, no significant differences were found between or within groups at any time point in the study [Age (F(6,23)=2.221, p=0.091) and Albumin (F(6, 23)=2.256, p=0.087) on the AAS, Age (F(6, 23)=1.864, p=0.146) and Albumin (F(6,23)=1.330, p=0.298) on the MAS].

Table 4. Scores for Sub-scales of the Chronic Disease Self-Efficacy Scale

CDSES SUBSCALE	Exercise Group (*n*=4)	Control Group (*n*=4)
Exercise Regularly		
PRE	9.6±0.9	8.0±3.4
POST	9.0±2.0	9.6±0.9
FUP	8.8±1.7	8.1±2.0
Get Info About Disease		
PRE	8.8±1.9	8.5±1.0
POST	8.0±2.8	8.8±2.5
FUP	9.0±0.8	10.0±0.0
Obtain Help from Community, Family, Friends		
PRE	8.6±1.6	7.0±1.5
POST	8.9±1.4	7.8±1.5
FUP	9.0±0.8	9.2±1.2*
Communicate with Physician		
PRE	8.6±2.6	7.6±2.0
POST	9.3±1.3	9.0±1.6
FUP	8.8±1.3	9.1±1.4
Manage Disease		
PRE	8.4±2.2	9.1±0.8
POST	9.2±1.0	9.0±1.2
FUP	8.4±1.3	9.0±1.1
Do Chores		
PRE	9.8±0.5	9.6±0.9
POST	9.7±0.7	8.4±1.2
FUP	9.1±1.1	9.2±0.7
Social/Recreational		
PRE	9.3±1.0	9.1±1.8
POST	9.4±0.8	9.3±1.5
FUP	8.6±1.4	9.4±1.3
Manage Symptoms		
PRE	8.3±2.2	7.8±1.5
POST	8.3±2.8	8.3±1.4
FUP	8.6±1.3	8.3±1.3
Manage Shortness of Breath		
PRE	9.3±1.0	8.5±2.4
POST	9.8±0.5	9.3±1.2
FUP	9.8±0.5	8.3±2.4
Control/ Manage Depression		
PRE	8.4±2.4	8.6±0.9
POST	8.4±2.8	8.5±1.9
FUP	8.7±1.3	9.3±0.7

Values are means ± standard deviations for the 10 sub-scales of the CDSES for the Exercise and Control groups. Sub-scale scores are out of a maximum of 10. PRE, prior to intervention; POST, end of 8-week intervention; FUP, 8-weeks post-intervention. (*) represents a significant difference from PRE value within the group at $p<0.05$.

Table 5. The Maximal Activity Scores following Adjustments for Age and Albumin

	ACTUAL MAS VALUES		ADJUSTED MAS VALUES					
			COVARIATE: AGE*		COVARIATE: ALBUMIN		COVARIATE: AGE + ALBUMIN	
	EX	CON	EX	CON	EX	CON	EX	CON
PRE	81.5±9.0	74.2±14.8	79.6±5.4	76.1±5.4	78.9±5.9	74.6±5.8	78.1±5.4	76.1±5.3
POST	84.5±9.8	74.2±14.8	82.6±5.4	76.1±5.4	90.9±6.0	78.1±6.1	80.5±5.4	78.5±5.5
FUP	82.0±8.5	73.2±16.2	80.1±5.4	75.1±5.4	78.9±6.0	78.1±6.2	78.3±5.4	78.2±5.6

Values are means ± standard errors for the adjusted MAS for the Exercise (EX) and Control (CON) groups. Actual MAS values are reported as means ± standard deviations. Maximum score for MAS is 94. PRE, prior to the intervention; POST, end of 8-week intervention; FUP, 8-weeks post-intervention; MAS, maximal activity score. (*) represents a significant influence on MAS at $p<0.05$.

Table 6. The Adjusted Activity Scores following Adjustments for Age and Albumin

	ACTUAL AAS VALUES		ADJUSTED AAS VALUES					
			COVARIATE: AGE*		COVARIATE: ALBUMIN*		COVARIATE: AGE + ALBUMIN	
	EX	CON	EX	CON	EX	CON	EX	CON
PRE	81.5±9.0	67.8±17.8	79.0±7.3	70.1±7.3	77.5±7.4	68.4±7.2	76.6±6.8	70.1±6.7
POST	84.5±9.8	67.5±22.2	82.1±7.3	69.9±7.3	79.0±7.5	73.5±7.6	78.4±6.9	74.0±7.0
FUP	82.0±8.5	67.0±24.1	79.6±7.3	69.4±7.3	77.2±7.4	74.6±7.8	76.5±6.8	74.7±7.2

Values are means ± standard errors for the adjusted AAS for the Exercise (EX) and Control (CON) groups. Actual AAS values are reported as means ± standard deviations. Maximum score for AAS is 94. PRE, prior to the intervention; POST, end of 8-week intervention; FUP, 8-weeks post-intervention; AAS, adjusted activity score. (*) represents a significant influence on AAS at $p<0.05$.

The mean values ± standard errors for the scores of the total CDSES adjusted for age alone, albumin alone, and age and albumin are listed in Table 7. Neither age nor serum albumin levels were found to be associated with the total scores of the CDSES. Considering the results of the ANCOVA for the scores of the HAP, age and serum albumin levels may also have been associated with self-efficacy for physical activity. Therefore, the Exercise Regularly, Do Chores, and Participate in Social and Recreational Activities sub-scale scores were evaluated independently since their items pertained to performing physical activity. Serum albumin concentrations were significantly associated with the scores of the Exercise Regularly and Do Chores scales ($F(1, 23)=14.986$, $p=0.001$ and $F(1, 23)=5.210$, $p=0.036$, respectively), while age was not. A significant relationship was found between the scores of the Participate in Social and Recreational Activities scale and age ($F(1, 23)=6.484$, $p=0.21$), but not serum albumin levels.

The mean values ± standard error for the ESES scores are listed in Table 8. Neither age nor serum albumin were found to be associated with the values of the ESES.

Table 7. The Scores of the Total Chronic Disease Self-Efficacy Scale and the Exercise Regularly, Do Chores, and Participate in Social and Recreational Activities Sub-Scales Adjusted for Age and Albumin

	ACTUAL CDSES VALUES		ADJUSTED CDSES VALUES					
			COVARIATE: AGE		COVARIATE: ALBUMIN		COVARIATE: AGE + ALBUMIN	
	EX	CON	EX	CON	EX	CON	EX	CON
CDSES TOTAL								
PRE	8.7±1.7	8.2±0.8	8.8±0.6	8.1±0.6	8.6±0.7	8.2±0.7	8.7±0.6	8.1±0.6
POST	8.8±1.8	8.6±1.3	9.0±0.6	8.4±0.6	8.7±0.7	8.8±0.7	8.7±0.6	8.7±0.6
FUP	8.7±1.1	8.8±0.8	8.8±0.6	8.7±0.6	8.6±0.7	9.1±0.7	8.6±0.6	9.1±0.7
EXERCISE REGULARLY SCALE†								
PRE	9.6±0.8	8.0±3.4	9.6±1.0	8.0±1.0	9.0±0.8	8.1±0.7	9.0±0.8	8.0±0.7
POST	9.0±2.0	9.6±0.8	9.0±1.0	9.6±1.0	8.1±0.8	10.5±0.8	8.2±0.8	10.5±0.8
FUP	8.8±1.7	8.1±2.0	8.8±1.0	8.1±1.0	8.1±0.8	9.2±0.8	8.2±0.8	9.2±0.8
DO CHORES SCALE†								
PRE	9.7±0.5	9.6±0.9	9.7±0.4	9.6±0.4	9.6±0.4	9.6±0.4	9.5±0.4	9.6±0.4
POST	9.7±0.7	8.4±1.2	9.6±0.4	8.4±0.4	9.4±0.4	8.7±0.4	9.4±0.4	8.7±0.4
FUP	9.1±1.1	9.2±0.7	9.0±0.4	9.2±0.4	8.8±0.4	9.5±0.4	8.8±0.4	9.5±0.4
SOCIAL/RECREATIONAL ACTIVITIES‡								
PRE	9.2±1.0	9.1±1.8	9.4±0.6	8.9±0.6	9.3±0.7	9.1±0.7	9.4±0.6	8.9±0.6
POST	9.4±0.8	9.2±1.5	9.6±0.6	9.1±0.6	9.5±0.7	9.1±0.7	9.6±0.6	9.1±0.6
FUP	8.6±1.4	9.4±1.2	8.8±0.6	9.2±0.6	8.7±0.7	9.2±0.7	8.8±0.6	9.2±0.6

Values are means ± standard errors for the adjusted scores of the CDSES for the Exercise (EX) and Control (CON) groups. Actual CDSES values are reported as means ± standard deviations. Maximum score for the subscale is 10. PRE, prior to intervention; POST, end of 8-week intervention; FUP, 8-weeks post-intervention; CDSES, Chronic Disease Self-Efficacy Scale. (†) represents a significant association of the sub-scale with serum albumin concentration and (‡) represents a significant association of the sub-scale with age $p<0.05$.

Table 8. The Scores of the Exercise Self-Efficacy Scale Adjusted for Age and Albumin

	ACTUAL ESES VALUES		ADJUSTED ESES VALUES					
			COVARIATE: AGE		COVARIATE: ALBUMIN		COVARIATE: AGE + ALBUMIN	
	EX	CON	EX	CON	EX	CON	EX	CON
ESES								
PRE	36.0±7.3	36.8±5.2	36.0±2.9	34.5±2.9	34.9±2.6	34.7±2.6	35.0±2.7	34.5±2.6
POST	34.5±4.4	32.5±5.1	36.7±2.9	32.5±2.9	35.2±2.7	34.2±2.7	35.3±2.7	34.1±2.8
FUP	35.2±5.7	34.6±5.3	35.8±2.9	33.8±2.9	34.2±2.6	35.8±2.8	34.3±2.7	35.8±2.8

Values are means ± standard errors for the adjusted scores of the ESES for the Exercise (EX) and Control (CON) groups. Actual ESES values are reported as means ± standard deviations. Maximum score for the subscale is 40. PRE, prior to intervention; POST, end of 8-week intervention; FUP, 8-weeks post-intervention; ESES, Exercise Self-Efficacy Scale.

Chapter 5

Discussion

5.1 Primary Findings

The primary findings of the current study were that no significant changes in physical activity or self-efficacy occurred in either the Exercise group or the Control group at the end of the exercise program or at 8-weeks of follow-up. Both groups reported relatively high levels of physical activity and self-efficacy at baseline which left only a small margin for improvement. The small sample size in combination with this ceiling effect most likely contributed to the lack of significant findings in this study. Age tended to be lower and serum albumin concentrations tended to be higher in the Exercise group as compared to the Control group. While these values were not statistically different between the two groups, most likely due to low statistical power arising from the small sample size, there was some concern these differences may have contributed to the relatively higher Maximal Activity Score and Adjusted Activity Score values in the Exercise Group as compared to the Control group. Subsequent analysis of co-variance indicated that both MAS and AAS were significantly associated with both age and albumin.

The baseline MAS and AAS values reported by the participants of this study were unusually high compared to values of approximately 60 (MAS) and 45 (AAS) recently reported for dialysis patients (n=1,628) in the 2009 USRDS Annual Data Report (U.S. Renal Data System, 2009), and of 55.2±14.9 (MAS) and 43.6±19 (AAS) reported by Fix & Daughton (1988). Interestingly, the MAS and AAS values in both the Control and Exercise groups were similar to those of healthy individuals (85.3±7.0 and 83.2±7.8, respectively) (Fix & Daughton, 1988).

The MAS provides an indication of an individual's physical capacity since it identifies the highest oxygen-demanding activity an individual is able to perform. The AAS is considered to be a measure of usual physical activity since it reflects the range of activities an individual is still doing (Davidson & de Morton, 2007). Additionally, because it provides an indication of how an individual is functioning within their maximal energy capacity, the AAS may be viewed as an indicator of functional ability. The MAS and AAS values in this study depict a group of individuals whose physical capacity, physical function, and physical activity levels are greater than that in the general ESRD population, and similar to healthy individuals. These findings are inconsistent with the well-documented belief that individuals with ESRD are typically sedentary and have severely impaired exercise capacities and physical function compared to their healthy sedentary counterparts (Cheema & Singh, 2005; Johansen et al., 2000; Kouidi, 2001; Painter et al., 2000b; Painter, 2005). Therefore, the participants in this study represent a select sub-group of the ESRD population. Similar findings have been reported by Fassett *et al.* (2009) who found that in a population of chronic kidney disease patients (n=120) there was a subset of individuals who participated in high levels of physical activity. They found that chronic kidney disease patients who reported participating in nationally recommended levels of physical activity (600 $MET\cdot min\cdot week^{-1}$) far exceeded the recommendations and performed high levels of physical activity (2,432±2,174 $MET\cdot min\cdot week^{-1}$). In contrast, chronic kidney disease patients who did not meet the recommendations for physical activity typically performed considerably less activity than recommended and significantly less activity (223±169 $MET\cdot min\cdot week^{-1}$) than those who participated in the recommended levels of physical activity. Similarly, Brenner and Brohart (2008) found a significant discrepancy in the levels of weekly physical activity energy expenditure between those who scored high on their MET scores (top 50% in group) compared to those who scored low (lower 50% in group); individuals who participated in higher energy cost activities typically had significantly greater weekly physical activity energy expenditures. Additionally, the participants in the high MET score group were more likely than the lower MET score group to participate in a variety of activities including hockey, skating, running, cycling, swimming, weight lifting, and conditioning exercises (Brenner & Brohart, 2008). Further, Fassett *et al.* (2009), using a multivariate analysis, showed that neither stage of disease nor cause of chronic kidney disease was associated with physical activity levels. The results of these studies, and the current one, suggest that renal failure per se is not necessarily a limitation to achieving recommended levels of physical activity.

The estimates of activity energy expenditure from the physical activity diaries were expected to be similar to the results of the HAP; greater than the values reported in the general ESRD population, and similar to those of healthy individuals. However, quantitative analysis of the diaries was not in agreement with the findings from the HAP; both the Exercise and Control group had low mean weekly estimated activity energy expenditures compared with self-reported values in the healthy and ESRD population. Johansen *et al.* (2000) reported that the daily estimated physical activity energy expenditure, as determined by the 7-day Physical Activity Recall Questionnaire, in 34 HD patients was 33.6±0.5 kcal·kg^{-1}. For the average 70 kg individual that would translate into approximately 16,464 kcal per week. Further, the estimated daily activity energy expenditure for the healthy controls (n=80) was 36.3±0.5 kcal·kg^{-1}, or approximately 18,787 kcal per week for a 70 kg individual. Therefore, not only does it appear that the individuals in our study were participating in substantively less physical activity than healthy individuals, but they were also less physically active then their ESRD counterparts. Most people overrate their physical activity on self-report questionnaires, and thus resulting energy expenditures tend to be overestimates (Warms, 2006). In contrast, weekly energy expenditure determined by accelerometry was similar to the values from this study. Majchrzak *et al.* (2005)

reported that the weekly activity energy expenditure in 20 HD patients was 509±288 kcal per day. Therefore individuals at the higher end of the spectrum would be expending approximately 5,579 kcal per week, similar to the values reported in this study.

The discrepancy between the HAP scores and estimated physical activity energy expenditures may be due to inconsistencies in daily activity recording. The accuracy of a physical activity diary is determined by the diligence, motivation, and commitment of participants to record their daily activities (Valanou et al., 2006). These constructs are influenced by many factors and fluctuate frequently, which can lead to large intra-individual variability in activity recordings. Further, qualitative analysis of the diaries revealed that the types of activities being recorded varied between participants. Those participants who regularly engaged in high-intensity physical activity tended to record more conventional forms of physical activity and neglected to report activities of daily living. Consequently, even though they regularly participated in high energy cost physical activities, such behaviour was not reflected in their weekly energy expenditures since higher intensity activities tend to be of shorter duration and performed less frequently than lower intensity activities, such as those of daily living. Accordingly, the participants who reported performing only basic activities of daily living were found to have greater energy expenditures. Despite their relative low intensities, activities of daily living can generate relatively large energy expenditure values because when accumulated over a week they result in long durations and high frequencies of activity. The ability of physical activity diaries to provide accurate estimates of energy expenditure is limited to measuring the energy expenditures of populations or large groups (Kalkwarf *et al.*, 1988; Geissler *et al.*, 1986; Acheson *et al.*, 1980; Borel *et al.*, 1984). The error associated with individual estimates of energy expenditure is too great for such estimates to be considered reliable. The large variability associated with the weekly estimates of physical activity energy expenditure in this study were consistent with this orthodoxy and is a testament to the fact that physical activity diaries are not accurate indices of energy expenditure in small sample sizes.

The findings of this study also highlight the importance of providing adequate levels of instruction for individuals to properly complete the diaries so that inaccuracies are minimized. Wormald *et al.* (2003) have previously alluded to the necessity of implementing effective instructional strategies when employing physical activity diaries. They found that inaccuracies, particularly in terms of duration (i.e. differentiating between time spent involved in an activity and the time spent actually performing the activity) and intensity, were reduced and data were more credible when a more comprehensive instructional strategy was introduced to participants.

The baseline levels of self-efficacy for exercise and disease self-management indicated that participants in the current study were highly efficacious compared with the general ESRD population and other chronic disease populations. In a recent study by Kack *et al*. (2010), the mean values of the ESES and the CDSES in 132 ESRD patients were 27.6±7.7 and 6.9±1.8, respectively; lower than the efficacy values reported by participants in this study. To our knowledge, the ESES has not been used in chronic disease populations other than those with spinal cord injury (Kroll et al., 2007) and multiple sclerosis (Stroud et al., 2009), but other measures of exercise self-efficacy in other chronic disease populations have shown levels of exercise self-efficacy similar to those reported by Kack *et al*. (2010) (50-70%, on a scale from 0%, being not confident at all, to 100% , being completely confident) (Carlson et al., 2001; Culos-Reed & Brawley, 2000; Heppner, Morgan, Kaplan, & Ries, 2006; Hospes, Bossenbroek, ten Hacken, van Hengel, & de Greef, 2009; Jeng et al., 2002; Lorig et al., 1996). Normative values for the sub-scales of the CDSES in chronic disease populations including those with heart and lung disease, stroke, and arthritis are lower than the values reported in this study, ranging from 5.87-7.37 (Lorig et al., 1996); suggesting a greater degree of confidence in the participants of this study to manage their disease compared with other individuals living with a chronic disease. Further, compared with the values reported in this study, similar levels of exercise self-efficacy were reported in a group of healthy older sedentary adults (mean age 65±5.5 years) (94%, on a scale from 0% being not confident at all, to 100%, being completely confident) (McAuley, Jerome, Marquez, Elavsky, & Blissmer, 2003b), suggesting that the participants in this study had similar levels of confidence to perform physical activity as healthy sedentary individuals. Because self-efficacy appears to be most influential when situations present the greatest challenge, its utility has been investigated primarily in sedentary individuals or in those for whom participation in physical activity presents a large challenge. However, the majority of participants in this study were high functioning and already engaging in some form of regular physical activity, therefore it is not surprising that they exhibited high levels of exercise self-efficacy compared with values in the literature.

The lack of change in self-efficacy observed in the Exercise group may have been due to an insufficient degree of challenge incorporated into the exercise program. In order for efficacy cognitions to be engaged a task must be deemed challenging. Cognitive control systems are most salient during the acquisition of behaviour proficiencies, but when behaviours are less demanding and more easily engaged in, cognitive control systems give way to lower control systems (Bandura & Wood, 1989). Given the high physical functioning of the participants in this study, the task may not have been considered high-demand and thus it is possible that efficacy cognitions were not salient in initiating and performing the low-intensity intra-dialytic cycling. Further, the realization of and satisfaction with progress with an exercise program serves to enhance self-efficacy (McAuley et al., 2003b), suggesting that changes in exercise intensity or duration may be crucial for maximizing increases in exercise self-efficacy. Supporting this orthodoxy, Neupert et al. (2009) found that changes in exercise intensity were predictive of changes in exercise self-efficacy (R^2= 0.20-0.33, p<0.05-p<0.001); as participants increased their exercise intensity and strength, concurrent increases in self-efficacy were observed. Tangentially, goal-setting and feedback of progress have been identified as integral parts of health promotion interventions among individuals with chronic diseases (Marks, Allegrant, & Lorig, 2005). Specifically, it is suggested that interventions intended to increase exercise self-efficacy encourage participation in "regular, goal-directed programs rather than programs implemented on the bases of individual's prevailing pain state" (Marks et al., 2005). However, in this study, the exercise program did not have set progressions; the work rate was based on a self-selected intensity and pace, consequently most participants worked at a fairly constant load for the duration of the exercise intervention. Progression in an exercise program, whether through increased duration or intensity, acknowledges improvements in personal capabilities and thus serves to increase efficacy cognitions. Therefore, the lack of gradual increase in exercise difficulty in this study may have contributed to the absence of improvements in self-efficacy since perceptions of enhanced capability are unlikely to be precipitated without overcoming a challenge. This may be a particularly pertinent consideration given the initial high physical capacity and efficacy levels of these participants.

Although the majority of individuals in the Control group wanted to engage in intra-dialytic cycling during the 8-week post-intervention period, only one of the four participants was able to participate. Many exercise sessions were forgone or stopped due to feelings of malaise and difficulty maintaining safe blood pressures during cycling in this one individual. Two participants from the Control group who wished to begin intra-dialytic cycling had to discontinue due to complications associated with the disease (hyperparathyroidism and associated joint pain) and the dialysis treatment itself (unsafe increases in venous fistula pressure). Frequent, successful performance of a behaviour facilitates the construction of a more efficacious belief system by providing consistent reinforcement of one's capability to succeed in a given task. Therefore, the lack of increase in exercise self-efficacy in the Control group may have been due to an inadequate number of mastery experiences performed by the participants. McAuley *et al.* (2003b) reported similar results, they found the frequency of an exercise activity to be predictive of exercise self-efficacy. In a self-efficacy-enhancing exercise intervention in 174 sedentary older adults, those who participated more frequently in the exercise intervention reported a more robust sense of self-efficacy at the end of a program. McAuley *et al*. (2003b) proposed that frequency of exercise participation affected perceived self-efficacy both directly and indirectly through greater social support and positive exercise affect.

Additionally, and perhaps of greater likelihood is that the lack of increase in self-efficacy and physical activity in both the Exercise and Control group may have been a result of an inability to statistically detect changes in these outcomes. The self-reported high baseline levels of physical activity and exercise self-efficacy may have contributed to a ceiling effect which, combined with a small sample size, could have prevented the detection of statistically significant improvements in physical activity or exercise self-efficacy. Physical activity is a complex phenomenon determined by the interplay of many variables and not just by self-efficacy. Therefore, it is possible that individuals had adequate levels of exercise self-efficacy but that other factors, such as monetary or social factors, impeded their participation in physical activity. Further, although we were expecting the experiences gained during the intra-dialytic cycling program to translate into increased self-efficacy to participate in greater daily physical activity, self-efficacy is specific to a task or situation and thus increases in self-efficacy would likely have occurred in a task-specific manner (i.e. performing aerobic exercise). However, the ESES primarily evaluated barrier self-efficacy, and may not have been appropriate to detect changes in task-specific self-efficacy.

Although it seems intuitive that self-efficacy should increase throughout an exercise program, some studies have reported that self-efficacy levels were unchanged or even decreased at the end of an exercise intervention (McAuley et al., 2003b; McAuley et al., 2004; Millen & Bray, 2008; Neupert et al., 2009). The decrease in self-efficacy was attributed to feelings of trepidation elicited by the proximity of the program's termination and the ensuing increased saliency of challenges associated with having to exercise independently. Since most participants in this study were already regularly active, this point may not be particularly relevant to these findings; however, it has important implications for the design of future exercise programs for the general, typically sedentary, ESRD population. It suggests that providing strategies to boost self-efficacy at the end of a program may be pivotal in enhancing maintenance of long-term exercise.

An analysis of covariance revealed that age was significantly associated with the MAS and AAS and the Participate in Social and Recreational Activities sub-scale of the CDSES, while serum albumin concentrations were significantly related to the AAS and the Exercise Regularly and Do Chores sub-scales of the CDSES. It is not surprising that age contributed to physical activity and physical function levels in the ESRD population as similar results have been well-documented in this population (Allen & Gappmaier, 2001; Johansen et al., 2000; Johansen et al., 2001a; Stack & Murthy, 2008; Zamojska et al., 2006). Johansen *et al.* (2000) found significant correlations between age and measures of physical activity (r=-0.65) and physical performance (gait speed r=-0.63; stair-climbing time r=0.41; chair-rising time r=0.51). Further, age has been suggested to be a particularly potent predictor of physical activity in HD patients since physical activity levels were found to decline at a considerably more rapid pace in dialysis patients compared to their healthy sedentary counterparts (Johansen et al., 2000). The relationship between serum albumin and physical activity and functional ability in the current study is in agreement with findings of others who have reported robust associations between serum albumin and physical activity and functional ability in this cohort (Allen & Gappmaier, 2001; Johansen et al., 2000; Johansen et al., 2001a; Laws, Tapsell, & Kelly, 2000; Stack & Murthy, 2008; U.S. Renal Data System, 2009; Zamojska et al., 2006). The nutrition sub-study of the Comprehensive Dialysis Study (CDS) found that in 269 ESRD patients, serum albumin was significantly associated with physical activity and physical function as measured by the HAP; those with higher serum albumin concentrations reported higher MAS and AAS values ($p<0.05$) (U.S. Renal Data System, 2009). Additionally, univariate and multivariate analyses revealed that serum albumin concentrations were significantly associated with objective measures of physical activity including accelerometry (r=0.58, $p=0.003$) (Johansen et al., 2000) and pedometry ($r=0.32$, $p=0.01$) (Zamojska et al., 2006) in HD patients. Using data from the DMMS Wave 2 study (n=2,264), Stack and Murthy (2008) found that those who reported limitations in moderate and vigorous activity had significantly lower levels of serum albumin; an odds ratio indicated that those who reported few limitations in moderate activity were significantly more likely to have higher serum albumin (OR=1.69 per 1g/dL higher). Measures of serum albumin have also been strongly associated with performance-based measures of physical performance in HD patients including gait speed (r=0.44, $p=0.002$), stair-climbing time (r=-0.32, $p=0.03$), and chair-rising time (r=-0.43, $p<0.003$) (Johansen et al., 2001a). Further, low serum albumin concentrations have been reported to be independently associated with decreased self-reported physical function (Allen & Gappmaier, 2001; Ohri-Vachaspati & Sehgal, 1999). In 289 HD patients, a 10 g/L decrease in serum albumin was associated with a 9-point reduction in physical function score on the Kidney Disease Quality of Life Questionnaire ($\beta=0.9$, $p=0.02$) (Ohri-Vachaspati & Sehgal, 1999).

Serum albumin would likely influence physical activity and physical function primarily through its role in nutrition and adequate muscle mass and muscle strength. Low levels of serum albumin are typically associated with a state of protein-energy malnutrition (Skouroliakou et al., 2009). Malnutrition affects skeletal muscle, connective tissue, the immune system, and plasma proteins, which can lead to a diverse range of systemic sequelae, particularly impaired muscle function (Skouroliakou et al., 2009). Muscle atrophy, one of the most pronounced results of malnutrition, is likely a major contributor to reduced physical function in the dialysis population (Johansen et al., 2003b; Skouroliakou et al., 2009). Johansen *et al.* (2003b) have reported that strength levels (maximal voluntary contraction) relative to total compartment cross-sectional area (CSA) were significantly lower in HD patients than in healthy sedentary controls, but when strength was adjusted for area of contractile CSA no significant differences existed, suggesting that muscle weakness was directly related to muscle atrophy in this population. Contractile CSA and muscle strength have been found to be significantly associated with gait speed (r=0.61and r=0.47, respectively) (Johansen et al., 2003b), while muscle strength has also been related to measures of exercise capacity including VO_{2peak} in the HD population (r=0.73 to 0.84, $p<0.05$ to $p<0.01$) (Diesel et al., 1990). Therefore, although the differences in serum albumin between the Exercise and Control groups were not significantly different, the lower mean serum albumin concentration in the Control group may have contributed to the prevailing trend of less physical activity and lower physical function this group.

Serum albumin is the most commonly used nutritional marker in dialysis patients; however, it is also a measure of renal function and is an indicator of albumin losses in the urine (and/or dialysate), the presence of inflammatory reactions, systemic disease, old age, and degree of dehydration (Heimbürger, Qureshi, Blaner, Berglund, & Stenvinkel, 2000). In dialysis patients, serum albumin levels have been suggested to be related more to a chronic inflammatory response than nutritional status (Bergström, Heimbürger, Lindholm, & Qureshi, 1995; Heimbürger et al., 2000; Kaysen, 1998). Heimbürger *et al.* (2000) found that serum albumin was more closely related to the inflammatory marker C-reactive protein (CRP) than to other measures of nutritional status including transthyretin (pre-albumin) and retinol-binding protein, and suggested that the association between serum albumin and malnutrition is likely related, in part, to a chronic, low-grade inflammatory response. Therefore, the influence of serum albumin on physical activity and physical function levels may be mediated via a duel mechanism of inflammation and malnutrition. However, in the nutrition sub-study of the Comprehensive Dialysis Study (n=265), serum albumin was found to be significantly associated with physical activity and physical function levels, while CRP and alpha-I acid glycoprotein (inflammatory marker) were not (U.S. Renal Data System, 2009), suggesting that the nutritional component of serum albumin may be a more salient correlate of physical activity.

Age and serum albumin were found to influence perceptions of personal competencies for performing exercise and physical activity. To our knowledge, this is the first study to investigate the relationship between self-efficacy and exercise in the ESRD population, thus there are no comparative data. The influence of serum albumin concentrations on exercise self-efficacy may be mediated through its role in nutritional status. Specifically, malnutrition and the ensuing systemic complications can lead to impaired muscle function, gut function, wound healing, and ventilatory response (Skouroliakou et al., 2009). Major sources of information used to develop expectations of personal efficacy are physiological and affective states (Bandura, 1997). Cognitive evaluation of information conveyed by anxiety arousal, fatigue, and feelings of muscular strain and fatigue influence personal efficacy expectations; somatic sensations are often interpreted as an inability to successfully complete a course of action (McAuley & Courneya, 1993). Therefore, the impact of any physiological cues from such impairments may negatively impact an individual's affective state, inhibiting the construction of positive efficacy beliefs and promoting the formation of negative efficacy beliefs. Perhaps of particular relevance to exercise self-efficacy is the effect of poor nutritional status on muscle strength and physical function. Low serum albumin concentrations have been directly related to decreased muscle mass (Kaizu et al., 2003; Ohkawa et al., 2000), which, in turn, has been associated with reduced skeletal muscle strength (Johansen et al., 2003b). Reduction in strength has been found to be an important predictor of physical performance (Johansen et al., 2003b) and exercise capacity (Diesel et al., 1990). Muscle weakness and impaired exercise capacity likely elicit physiological responses during exercise that are uncomfortable and maximize negative affect, potentially undermining efficacy expectations and seriously reducing one's confidence to participate in physical activity.

Although depression was not assessed in this study, it is prevalent in the ESRD population and is associated with serum albumin concentrations in HD patients ($r=0.47$, $p<0.001$) (Koo et al., 2003). Those with lower serum albumin levels have been found to have significantly greater levels of depression (Huang & Lee, 2007; Koo et al., 2003). Depression is "cognitively generated by dejecting thought patterns and frequently contributes to perceptions of personal inadequacies" (Bandura, 1990). Therefore, depression levels may negatively impact personal competencies for exercise and physical activity participation in this population. In cancer survivors (n=282), mental health, as measured by the Center for Epidemiological Studies Depression Scale (CESD), was significantly associated with self-efficacy for physical activity ($\beta=0.15$, $p=0.001$) (Perkins, Baum, Taylor, & Basen-Engquist, 2009).

5.2 Limitations

The inclusion/exclusion criteria limited the sample population to those who were medically stable, ambulatory, and had no serious contraindications to exercise. Additionally, the participants in this study volunteered and thus may have had higher levels of motivation to participate in exercise and greater levels of self-efficacy for exercise than those in the general ESRD population. Consequently, the participants in this study were relatively high functioning and may not be an accurate representation of the ESRD population, limiting the generalizability of the results. However, the inclusion criteria of the current study would be required for any ESRD patient to safely participate in intra-dialytic exercise.

Inherent sources of error affecting the validity of the activity diary method included; a) error in the recording of activities, and b) the process of converting activities into corresponding energy expenditures. The main source of error in activity recording was due to problems associated with recall. The validity of physical activity diaries is dependent on a participant's ability to accurately remember, and diligently record, the duration and intensity of daily activities. Diaries are often tedious and inconvenient, placing a large burden on participants. Consequently, a high degree of motivation and commitment is required by the participant to ensure that accurate estimates of energy expenditure can be determined; making their use in longer studies difficult. In this study, it was evident that the length of data collection negatively affected participant motivation and diligence to record activities. As the study progressed, the quality of the diary information diminished; accounts of daily activities became sparse and were inconsistent with previously recorded activity behaviour. Further, recall bias, particularly social desirability recording, is a concern with any self-report measure. Most people overrate their levels of physical activity leading to gross overestimates of energy expenditure and/or physical activity levels. Although estimates of energy expenditure were low in this study, it was more likely due to reduced diligence in daily logging than underrating levels of physical activity.

The use of published energy-cost values from The Compendium of Physical Activities (Ainsworth et al., 2000) may also contribute to the error in physical activity diaries. The compendium was not developed to provide precise energy costs of physical activities within individuals (Ainsworth et al., 2000). The MET values in the compendium are based on averages and do not take into account individual differences that may alter energy costs such as age, body mass, and fat percentage (Ainsworth et al., 2000). Consequently, the actual energy cost of an activity for a person may or may not be accurately represented by the MET value in the compendium since individual differences in energy expenditure for the same activity can be quite large. Further, the data in the compendium is intended for adults without conditions that significantly alter metabolic efficiency (Ainsworth et al., 2000). Thus, considering the small sample size of the study and the fact that individuals with ESRD typically experience metabolic inefficiencies the accuracy of the estimates of activity energy expenditure may have been affected.

Further, physical activity diaries are suggested only for use in measuring energy expenditure in large groups or populations (Kalkwarf et al., 1988; Geissler et al., 1986; Acheson et al., 1980; Borel et al., 1984). Large intra-personal variability in activity recording and activity energy costs results in a level of error that is too great for this method to provide accurate estimates of individual energy expenditure. Therefore, the unexpected small sample size may have compromised the validity of this tool, limiting the use of the quantitative data from the diaries.

5.3 Clinical Relevance/ Future Considerations

Due to the small sample size and resulting low statistical power, the results of this study are preliminary and should be interpreted with caution. However, consistent with the literature, age and serum albumin were significantly related to levels of physical activity and physical function in the HD population; therefore, both may be important determinants of physical activity in this population. Further, low serum albumin may also affect physical activity and physical function indirectly through reduced self-efficacy. This underscores the importance of maintaining an adequate nutritional status and monitoring serum albumin concentrations.

When recruiting participants for an exercise-based self-efficacy enhancing intervention it is important to consider their baseline levels of physical activity and exercise self-efficacy. In this study, the majority of the participants were high functioning, regularly active, efficacious individuals and thus a low-intensity exercise program would likely not provide a sufficient challenge to evoke changes in self-efficacy, and subsequently physical activity. Screening participants for physical activity and self-efficacy levels before the start of an exercise intervention may help to maximize the effect of the exercise program. If, similar to this study, a low-intensity exercise program is employed it is likely only to be effective in those who are deconditioned and would perceive such light work loads to be challenging. Excluding participants who are high functioning introduces a selection bias, while including them may mask the effectiveness of the intervention. Therefore, stratifying participants based on baseline measures of physical activity and self-efficacy may provide a better alternative as investigators can prescribe exercise programs that would be appropriate for varying levels of function.

Further, in addition to providing individuals with mastery experiences, it may be important to incorporate other learning strategies into the intervention which further provide participants with the tools to be physically active outside the dialysis unit (Marks et al., 2005). Specifically, increasing participants' confidence in their abilities to independently create and maintain physical activity and to adapt to challenges that they may encounter. Interactively identifying barriers to exercise/physical activity and problem solving to generate solutions and strategies to overcoming these barriers may aid in long-term adherence to independent exercise. In particular, developing efficacy for self-regulatory behaviours such as setting-goals, planning, problem solving, and self-monitoring has been suggested to help individuals successfully incorporate regular physical activity into their daily lives (Rovniak et al., 2002).

The selected measures of self-efficacy initially appeared to be suited for the purposes of this pilot study. They each provided a tool which had been previously validated and for which normative values were available for reference. Further, these scales were employed in a previous study in our lab, in which the participants in this study were a small subgroup of the sample, and thus normative values for these scales were available for individuals with ESRD. However, retrospectively they may not have been appropriate as their items did not reflect the specific domain of self-efficacy that the intra-dialytic exercise program was targeting. The use of a tool which predominately assessed barrier self-efficacy, when the program was developing task self-efficacy, may have contributed to the inability to detect a significant change in exercise self-efficacy. Therefore, it is important to select a measurement tool which is specific to the type of self-efficacy being targeted and sensitive to the types of changes in self-efficacy that are expected to be elicited by the exercise intervention. In future studies, it may be advisable to develop your own scale to ensure that the items reflect the specific aspects of self-efficacy being developed by the exercise intervention (i.e. the specific task). For example, “how confident are you that you can perform 30-minutes of continuous intra-dialytic cycling”, “how confident are you that you can perform 30-minutes of continuous intra-dialytic exercise when you are feeling fatigued”, or “how confident are you that you can perform 30-minutes of low/moderate/vigorous aerobic exercise.”

A major limitation of physical activity diaries is the poor ability to accurately capture activities of short duration. In sedentary populations spontaneous activities are the primary source of physical activity, making it difficult to determine changes in activity levels (Tudor-Locke & Myers, 2001). Specifically, walking behaviour is the least reliably recalled physical activity because people often have difficulty registering walking speed/pace or intensity, in both absolute and relative terms (Tudor-Locke & Myers, 2001). This has serious implications for measuring physical activity in the ESRD population since walking is the most common form of physical activity performed in this population (Fassell et al., 2008, Brenner & Brohart, 2008).

Motion sensors (i.e. pedometers and accelerometers) offer an accurate and objective measure of physical activity/energy expenditure; however, the costs associated with their use may not be feasible and consequently self-report measures would be the likely alternative. Therefore, it is important to focus on strategies that will improve an individual's ability to accurately estimate intensity levels. Developing effective instructional strategies which ensure sufficient time is spent providing instruction on how to accurately estimate and record the intensity and duration of walking and other activities may help to improve the accuracy of energy expenditure estimates.

Additionally, an outcome measure must be considered acceptable by the participants if they are going to actively participate. Completing the daily physical activity diary for the entire duration of this study placed a large demand on the participants, consequently the accuracy of the self-reported physical activity levels suffered. To improve the validity of this measurement tool, it may be advisable that diaries be used over a shorter period of time, perhaps administering them at intervals throughout the study (i.e. once every three weeks) rather than having participants complete the diaries on a continuous basis.

Although the results of this study showed no significant changes in physical activity or self-efficacy in either the Exercise or the Control group, it is important to remember that this study had insufficient power to conclude that an exercise program was ineffective in enhancing exercise self-efficacy and daily physical activity. Considering the robust evidence supporting the utility of self-efficacy enhancing exercise programs in the adoption and maintenance of physical activity in other chronic diseases and the general population, it is important to determine the role of self-efficacy in enhancing participation in physical activity in the HD population. Therefore, additional recruitment of participants is required to more clearly define the role of intra-dialytic exercise in enhancing exercise self-efficacy and physical activity in HD patients.

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Appendix A

1. Informed Consent Form
2. Research Ethics Approval Form

INFORMED CONSENT FORM

The Effects of an Intra-Dialytic Exercise Program on Self-Efficacy and Continued Physical Activity in Individuals with End-Stage Renal Disease

Volunteer to Participate

You have volunteered to participate in a research study in which you will be asked to complete questionnaires regarding your physical activity and your self-efficacy for exercise and various chronic disease self-management tasks and to complete a physical activity diary on a weekly basis. You will also be asked to participate in either a 12-week supervised intra-dialytic exercise program <u>OR</u> to be a member of the control group who does not participate in this exercise program.

Basis for Subject Selection

The reason you are able to take partake in this study is because you are 18 years of age of older, have been on hemodialysis for greater than 3 months, undergo hemodialysis in the Burr Wing Satellite Dialysis Unit at the Providence Care Mental Health Services site, and have medical clearance to participate in the exercise program.

Purpose of the Study

The purpose of the current study is to examine the effects of an intra-dialytic exercise program on self-efficacy and continued physical activity in individuals with end-stage renal disease. Self-efficacy is an individual's perception of his/her ability to perform a particular task. More specifically, we wish to examine whether participating in a supervised, low-intensity intra-dialytic exercise program increases self-efficacy for exercise and other daily activities and if it promotes increased physical activity levels and participation in social and recreational activities.

Explanation of Procedures

<u>1. Pre-intervention, Post-Intervention, and 12-Week Follow-Up</u>

There will be a 2-week pre-intervention period, a 12-week intervention period (exercise or no exercise) and a 12-week follow-up period. You will be asked to complete three questionnaires.

a) Physical Activity Diaries

Each participant will be requested to complete a weekly physical activity diary during the 2 weeks prior to the start of the 'intervention', and through the 12 weeks of intervention and follow-up period. In the physical activity diary, you will be asked to record your daily levels of physical activity each week. A new diary will be given to you at the beginning of each week.

b) Questionnaires

Two questionnaires will assess self-efficacy, one is a Chronic Disease Self-Management Questionnaire which consists of 34 questions and the other is an Exercise Self-Efficacy Questionnaire which contains 10 questions. The third questionnaire, the Human Activity Profile, is a 94-item scale which lists physical activities in order of increasing energy demand. It assesses your levels of physical activity and physical function. You will be asked to complete each of these questionnaires at the end of the pre-intervention, post-intervention and follow-up periods. These questionnaires can easily be completed during your dialysis session.

2. Intra-dialytic Exercise Program

If assigned to the exercise group, you will be asked to engage in exercise during each of your dialysis sessions for 12-weeks. The exercise program will consist of self-selected intensity exercise, either cycling or stepping, which is to be completed during the first two hours of your dialysis session. The goal is to achieve two 30-minute bouts of exercise during this time, but the duration of the exercise bout will be dependent on your initial physical capabilities. Your heart rate, blood pressure, and level of perceived of exertion will be monitored. During the following 12-weeks, the exercise equipment will be available for you to use if you so chose. The investigators will be present to monitor any intra-dialytic exercise that you choose to do.

3. Control Group

If assigned to the control group, you will continue to receive your dialysis treatment as normal. You will also be asked to carry on your daily activities as normal. However, should you wish to engage in intra-dialytic exercise during the 12-week period following the end of the exercise program, the investigators will be present to prescribe and monitor any intra-dialytic exercise that you choose to do.

Potential Risks and Discomfort

There are no anticipated risks or discomfort associated with completing the questionnaires, therefore those assigned to the control group are not expected to be at risk or experience any discomfort. Previous investigations have shown that when exercise is performed in the first two hours of dialysis there appears to be minimal risk to the person. For individuals not used to exercising there may be transient muscle soreness in 24 hours following the exercise session.

Potential Benefits

For those assigned to the experimental group, participating in an intra-dialytic exercise program may increase self-efficacy for exercise and other daily activities. It is anticipated that such increases in self-efficacy will be accompanied by increases in physical activity and participation in social and recreational activities. Additionally, regular physical activity has been found to attenuate some of the symptoms associated with the uremic syndrome, enhance physical function, and modify some cardiovascular risk factors.

While there may be no direct benefit to those assigned to the control group, the data from the study will help us to determine if an intra-dialytic exercise program can promote increases in physical activity and participation in social and recreational activities by increasing self-efficacy for exercise and other daily activities,. If this is the case, then it will provide additional rationale to support the argument for the inclusion of supervised intra-dialytic exercise programs in standard clinical care to optimize the overall health status of individuals with ESRD.

Financial Obligations
There are no financial obligations on your part for participation in this study.

Assurance of Confidentiality
Any information obtained in connection with this study will be held in strict confidence. Each participant will be assigned a participant code known only to the investigators. The database containing your results from the questionnaires will be in the form of a Microsoft Excel spreadsheet, the only identifier will be your participant code. Access to this Microsoft Excel file is limited to the investigators of this study. Any identifying information (i.e. the code sheet listing participant names and associated code) will be kept in a locked file cabinet in the Principal Investigator's laboratory and will not be available electronically. 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.

Offer to Answer Questions
If you have any questions, please do no hesitate to contact one of the students listed below, or Dr. Cheryl King-VanVlack, the Principal Investigator of the study, at 613-533-6341 (office) or 613-542-8042 (home).

If you have any concerns regarding the students' authorization to perform this study you may contact Dr. Elsie Culham, the Director, School of Rehabilitation Therapy & Associate Dean of Health Sciences at (613) 533-6727.

If you have any concern regarding the rights of research participants, you may contact Queen's University Research Ethics Board (REB) by telephone at (613) 533-6000 (ext 74579).

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 ADQUATE OPPORTUNITY TO DISCUSS THIS STUDY WITH THE INVESTIGATORS AND YOU HAVE HAD ALL YOUR QUESTIONS ANSWERED TO YOUR SATISFACTION. YOU WILL BE GIVEN A COPY OF THIS CONSENT FORM TO KEEP.

____________________________ ____________________________

Signature of Participant Date

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

____________________________ ____________________________

Signature of Investigator Date

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QUEEN'S UNIVERSITY HEALTH SCIENCES AND AFFILIATED TEACHING HOSPITALS
ANNUAL RENEWAL

Queen's
UNIVERSITY

Queen's University, in accordance with the "Tri-Council Policy Statement, 1998" prepared by the Medical Research Council, Natural Sciences and Engineering Research Council of Canada and Social Sciences and Humanities Research Council of Canada requires that research projects involving human subjects be reviewed annually to determine their acceptability on ethical grounds.

A Research Ethics Board composed of:

Dr. A.F. Clark	**Emeritus Professor, Department of Biochemistry, Faculty of Health Sciences, Queen's University (Chair)**
Dr. H. Abdollah	**Professor, Department of Medicine, Queen's University**
Rev. T. Deline	**Community Member**
Dr. M. Evans	**Community Member**
Dr. S. Irving	**Psychologist, Providence Care, St. Mary's of the Lake Hospital Site**
Prof. L. Keeping-Burke	**Assistant Professor, School of Nursing, Queen's University**
Mrs. J. Kotecha	**Research & Programs Manager, Centre for Studies in Primary Care, Department of Family Medicine, Queen's University**
Dr. J. Low	**Emeritus Professor, Department of Obstetrics and Gynaecology, Queen's University and Kingston General Hospital**
Dr. W. Racz	**Emeritus Professor, Department of Pharmacology & Toxicology, Queen's University**
Dr. B. Simchison	**Assistant Professor, Department of Anaesthesiology, Queen's University**
Dr. A.N. Singh	**WHO Professor in Psychosomatic Medicine and Psychopharmacology Professor of Psychiatry and Pharmacology Chair and Head, Division of Psychopharmacology, Queen's University Director & Chief of Psychiatry, Academic Unit, Quinte Health Care, Belleville General Hospital**
Dr. E. Tsai	**Associate Professor, Department of Paediatrics and Office of Bioethics, Queen's University**
Rev. J. Warren	**Community Member**
Ms. K. Weisbaum	**LL.B. and Adjunct Instructor, Department of Family Medicine (Bioethics)**
Dr. S. Wood	**Director, Office of Research Services (Ex Officio)**

has reviewed the request for renewal of Research Ethics Board approval for the project **"The Effect of Intermittent Submaximal Exercise on Dialysis Efficacy, Cardiovascular Function, and Quality of Life in End-Stage Renal Disease (ESRD)"** as proposed by Dr. Cheryl King-VanVlack of the School of Rehabilitation Therapy, at Queen's University. The approval is renewed for one year, effective June 29, 2009. If there are any further amendments or changes to the protocol affecting the subjects in this study, it is the responsibility of the principal investigator to notify the Research Ethics Board. Any unexpected serious adverse event occurring locally must be reported within 2 working days or earlier if required by the study sponsor. All other adverse events must be reported within 15 days after becoming aware of the information..

Albert Clark
Chair, Research Ethics Board

Sept 1, 2009
Date

ORIGINAL TO INVESTIGATOR - COPY TO DEPARTMENT HEAD- COPY TO HOSPITAL(S) - FILE COPY

Renewal 1[ ] Renewal 2 [ ] Extension [x]

REB# REH-132-01

Appendix B

Outcome Measures:

1. Participant Demographic Information
2. The Human Activity Profile
3. Daily Physical Activity Diary
4. Exercise Self-Efficacy Scale
5. Chronic Disease Self-Efficacy Scale

PARTICIPANT DEMOGRAPHIC INFORMATION FORM

Gender: ___________

Date of Birth: ___________ Age: _________

Kt/V: _____________

Primary Diagnosis:

____

Previously Received Kidney Transplant (circle): Y / N

Treatment History (including current):

Type of Dialysis (HD or PD)	Location of Fistula (L/ R arm or central line)	Dialysis Start Date	Dialysis Vintage (months)

MEDICATIONS	NOTES
Name:	Type:
Name:	Type:
Name:	Type:
Name:	Type:
Name:	Type:
Name:	Type:

Name:	Type:
Name:	Type:
Name:	Type:
Name:	Type:
Name:	Type:
Name:	Type:

COMORBIDITY	NOTES

OTHER RELEVANT INFORMATION:

Human Activity Profile

Please use the following instructions when making your responses:

Check Column 1 ("Still Doing This Activity") if:

You completed the activity unassisted the last time you had the need or opportunity to do so.

Check Column 2 ("Have Stopped Doing This Activity") if:

You have engaged in the activity in the past, but you probably would not perform the activity today even if the opportunity should arise.

Check Column 3 ("Never Did This Activity") if:

You have never engaged in the specific activity.

	Still Doing This Activity	Have Stopped Doing This Activity	Never Did This Activity
1. Getting in and out of chairs or bed (without assistance)			
2. Listening to the radio			
3. Reading books, magazines or newspapers			
4. Writing (letters, notes)			
5. Working at a desk or table			
6. Standing (for more than one minute)			
7. Standing (for more than five)			
8. Dressing or undressing (without assistance)			
9. Getting clothes from drawers or closets			
10. Getting in or out of a car (without assistance)			
11. Dining at a restaurant			
12. Playing cards/table games			
13. Taking a bath (no assistance needed)			
14. Putting on shoes, stockings or socks (no assistance needed)			
15. Attending a movie, play, church event or sports activity			
16. Walking 30 yards (27 meters)			
17. Walking 30 yards (non-stop)			

18. Dressing/undressing (no rest or break needed)			
19. Using public transportation or driving a car (100 miles or less)			
20. Using public transportation or driving a care (99 miles or more)			
21. Cooking your own meals			
22. Washing or drying dishes			
23. Putting groceries on shelves			
24. Ironing or folding clothes			
25. Dusting/polishing furniture or polishing cars			
26. Showering			
27. Climbing six steps			
28. Climbing six steps (non-stop)			
29. Climbing 9 steps			
30. Climbing 12 steps			
31. Walking ½ block on level ground			
32. Walking ½ block on level ground (non-stop)			
33. Making a bed (not changing sheets)			
34. Cleaning windows			
35. Kneeling, squatting to do light work			
36. Carrying a light load of groceries			
37. Climbing nine stops (non-stop)			
38. Climbing 12 steps (non-stop)			
39. Walking ½ block uphill			
40. Walking ½ block uphill (non-stop)			
41. Shopping (by yourself)			
42. Washing clothes (by yourself)			
43. Walking one block on level ground			
44. Walking two blocks on level ground			
45. Walking one block on level ground (non-stop)			
46. Walking two blocks on level ground (non-stop)			
47. Scrubbing (floors, walls, or cars)			
48. Making beds (changing sheets)			

49. Sweeping			
50. Sweeping (5 minutes non-stop)			
51. Carrying a large suitcase or bowling (one line)			
52. Vacuuming carpets			
53. Vacuuming carpets (5 minutes non-stop)			
54. Painting (interior/exterior)			
55. Walking six blocks on level ground			
56. Walking six blocks on level ground (non-stop)			
57. Carrying out the garbage			
58. Carrying a heavy load of groceries			
59. Climbing 24 steps			
60. Climbing 36 steps			
70. Climbing 24 steps (non-stop)			
71. Climbing 50 steps			
72. Shovelling, digging or spading			
73. Shovelling, digging, or spading (non-stop)			
74. Climbing 50 steps (non-stop)			
75. Walking three miles or golfing 18 holes without a riding cart			
76. Walking three miles (non-stop)			
77. Swimming 25 yards			
78. Swimming 25 yards (non-stop)			
79. Bicycling one mile			
80. Bicycling two miles			
81. Bicycling one mile (non-stop)			
82. Bicycling two miles (non-stop)			
83. Running or jogging ¼ mile			
84. Running or jogging ½ mile			

85. Playing tennis or racquetball			
86. Playing basketball (game play)			
87. Running or jogging ¼ mile (non-stop)			
88. Running or jogging ½ mile (non-stop)			
89. Running or jogging one mile			
90. Running or jogging two miles			
91. Running or jogging three miles			
92. Running or jogging one mile in 12 minutes or less			
93. Running or jogging two miles in 20 minutes or less			
94. Running or jogging three miles in 30 minutes or less			

FOR RESEARCH PROJECT STAFF ONLY	
MAS = Highest item number answered *Still Doing* **Maximum Activity Score (MAS)**	
Adjustment= Total number of *Stopped Doing* responses **below** the MAS **Adjustment**	
AAS = MAS – Adjustment **Adjusted Activity Score (AAS)**	

DAILY PHYSICAL ACTIVITY DIARY

Instructions:
This diary is for you to keep a record of all physical activity you do during a week.
Please:

1. Complete all sections of the diary for each day of the week, including weekends.
2. Record the type of activity (refer to the list of activity types below).
3. Record how long you spent doing the activity (in minutes).
4. Record how hard the activity was for you to engage in (refer to the explanations provided below).

Level of Exertion:
Light (easy): activity involves little body movement or slow body movement; you are not breathing hard.

Moderate: activity involves more body movement and/ or quick body movements; you are breathing harder but does not make you out of breath.

Vigorous (Hard): activity involves a lot of body movement and or quick body movements; doing this activity makes you out of breath and sweaty.

If you have any questions, please do not hesitate to contact one of the students listed below, or Dr. Cheryl King-VanVlack, the Principal Investigator of the study.

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DAILY PHYSICAL ACTIVITY DIARY

☐Monday ☐ Tuesday ☐Wednesday ☐Thursday

☐Friday ☐Saturday ☐Sunday

Date: _______________________

Time of Day	Activity	Duration (mins)	Level of Exertion
AM			
PM			
Night			

If you were not very active today, please indicate the reason(s) why: (i.e. did not feel well, other commitments, bad night sleep, etc..)

☐Monday ☐ Tuesday ☐Wednesday ☐Thursday

☐Friday ☐Saturday ☐Sunday

Date: _______________________

Time of Day	Activity	Duration (mins)	Level of Exertion
AM			
PM			
Night			

If you were not very active today, please indicate the reason(s) why: (i.e. did not feel well, other commitments, bad night sleep, etc..)

EXERCISE SELF-EFFICACY QUESTIONNAIRE

Please Read all of the following statements and indicate by circling the most appropriate answer how confident you are with regard to carrying out regular physical activities and exercise. Rate your answers according to the following 4-point scale.

1= Not True at All 2= Rarely True 3= Moderately True 4= Always True

I am confident…

1.	That I can overcome barriers and challenges with regard to physical activity and exercise if I try hard enough.	1	2	3	4
2.	That I can find means and ways to be physically active and exercise.	1	2	3	4
3.	That I can accomplish my physical activity and exercise goals that I set.	1	2	3	4
4.	That when I am confronted with a barrier to physical activity or exercise I can find several solutions to overcome this barrier.	1	2	3	4
5.	That I can be physically active or exercise even when I am tired.	1	2	3	4
6.	That I can be physically active or exercise even when I am feeling depressed.	1	2	3	4
7.	That I can be physically active or exercise without the support of my family or friends.	1	2	3	4
8.	That I can be physically active or exercise without the help of a therapist or trainer.	1	2	3	4
9.	That I can motivate myself to start being physically active or exercising again after I've stopped for a while.	1	2	3	4
10.	That I can be physically active or exercise even if I had no access to a gym, exercise, training, or rehabilitation facility.	1	2	3	4

CHRONIC DISEASE SELF-EFFICACY SCALE

Please Read all of the following statements and indicate by circling the most appropriate answer how confident you are with regard to carrying out various activities regularly at the present time. Rate your answers according to the following 10-point scale.

Not at all Confident	1	2	3	4	5	6	7	8	9	10	Totally Confident

	Rating
1. How confident are you that you can do gentle exercises for muscle strength and flexibility three to four times per week (range of motion, using weights, etc.)?	
2. How confident are you that you can do aerobic exercise such as walking, swimming, or bicycling three to four times each week?	
3. How confident are you that you can exercise without making symptoms worse?	
4. How confident are you that you can get information about your disease from community resources?	
5. How confident are you that you can get family and friends to help you with the things you need (such as household chores like shopping, cooking, or transport)?	
6. How confident are you that you can get emotional support from friends and family (such as listening or talking over your problems)?	
7. How confident are you that you can get emotional support from resources other than friends or family, if needed?	
8. How confident are you that you can get help with your daily tasks (such as housecleaning, yard work, meals, or personal hygiene) from resources other than friends or family, if needed?	
9. How confident are you that you can ask your doctor things about your illness that concerns you?	

10. How confident are you that you can discuss openly with your doctor any personal problems that may be related to your illness?	
11. How confident are you that you can get work out differences with your doctor when they arise?	
12. Having an illness often means doing different tasks and activities to manage your condition. How confident are you that you can do all the things necessary to manage your condition on a regular basis?	
13. How confident are you that you can judge when the changes in your illness mean you should visit a doctor?	
14. How confident are you that you can do the different tasks and activities needed to manage your health condition so as to reduce your need to see a doctor?	
15. How confident are you that you can reduce the emotional distress caused by your health condition so that it does not affect your everyday life?	
16. How confident are you that you can do things other than just taking medication to reduce how much your illness affects your everyday life?	
17. How confident are you that you can complete your household chores, such as vacuuming and yard work, despite your health problems?	
18. How confident are you that you can get your errands done despite your health problems?	
19. How confident are you that you can get your shopping done despite your health problems?	
20. How confident are you that you can continue to do your hobbies and recreation?	
21. How confident are you that you can continue to do the things you like to do with friends and family (such as social visits and recreation)?	

22. How confident are you that you can reduce your physical discomfort or pain?	
23. How confident are you that you can keep the fatigue caused by your disease from interfering with the things you want to do?	
24. How confident are you that you can keep the physical discomfort or pain of your disease from interfering with the things you want to do?	
25. How confident are you that you can keep any other symptoms or health problems you have from interfering with the things you want to do?	
26. How confident are you that you can control any symptoms or health problems you have so that they don't interfere with the things you want to do?	
27. How confident are you that you can keep your shortness of breath from interfering with what you want to do?	
28. How confident are you that you can keep from getting discouraged when nothing you do seems to make any difference?	
29. How confident are you that you can keep from feeling sad or down in the dumps?	
30. How confident are you that you can keep yourself from feeling lonely?	
31. How confident are you that you can do something to make yourself feel better when you are feeling lonely?	
32. How confident are you that you can do something to make yourself feel better when you are feeling discouraged?	
33. How confident are you that you can do something to make yourself feel better when you feel sad or down in the dumps?	

Appendix C

1. Percent of Intra-dialytic Exercise Sessions Completed per Week for each Participant

2. Number of Minutes of Intra-dialytic Exercise Performed per Week by each Participant

Percent of Intra-dialytic Exercise Session Completed per Week for each Participant

	Week of Study															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
E1	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	away
E2	100	100	100	100	100	100	100	100	100	0	100	100	100	100	100	100
E3	100	100	100	100	100	100	100	100	0	100	100	100	100	na	na	100
E4	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	away
C1																
C2									2†							
C3									100	100	100	100	50	0	100	33
C4									1‡							

E, Exercise group participant; C, Control group participant

†- number, not percent, of exercise sessions completed; participant was unable to continue with exercise program due to unsafe fistula venous pressures

‡- number, not percent, of exercise sessions completed; participant was unable to continue due to hip pain elicited during cycling

na- investigators were unavailable to monitor exercise

Number of Minutes of Intradialytic Exercise per Week for each Participant

	Week of Study															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
E1	180	180	180	180	180	120	60	180	180	120	120	180	180	180	180	away
E2	180	180	180	180	180	60	90	180	180	0	60	180	120	120	120	105
E3	50	60	45	120	120	60	60	45	0	45	60	60	40	0	0	45
E4	110	100	160	160	180	60	100	165	180	30	120	165	60	120	160	60
C1																
C2									115							
C3									60	20	60	60	20	0	67	30
C4									60							

E, Exercise group participant; C, Control group participant