Evaluation of an exercise program delivered prior to hemodialysis

by

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Abstract

Although it is broadly accepted that exercise offsets poor health outcomes experienced by hemodialysis patients, incorporating exercise into patients' lives remains a challenge. This study aimed to (1) determine the effects of a pragmatically-designed exercise program on physical performance, mental health, and quality of life of hemodialysis patients, and (2) explore patient and staff experiences with the exercise program at five dialysis units. Intervention participants were offered a thrice-weekly, 12-week exercise program at the unit prior to hemodialysis. Health-related quality of life (EQ-5D-5L Index Value) improved significantly for the exercise participants compared to control. Physical performance (Short Physical Performance Battery) and mental health (Center for Epidemiological Studies Depression Scale-Revised) did not change significantly. The majority of participants and staff reported positive feedback and benefits from the exercise program. In conclusion, a pragmatically-designed exercise program delivered before hemodialysis improved patients' quality of life and was well-received by patients and staff.

Keywords: hemodialysis; exercise; physical performance; health-related quality of life; community dialysis unit; physical activity

Dedication

I dedicate my thesis to Arnold and Dorothy Heckert, my wonderful, kind grandparents. I had the incredible opportunity to live with them while I completed my Bachelor's Degree. I will never forget riding the bus home from SFU, sharing supper with them, and telling them about my day. I treasure every memory of our evening routine of supper, a delicious dessert and infamous cookie, dishes (including the cutlery that "wash themselves"), studying, and settling in to watch some programs or "rest our eyes". I long to repeat it even one more time. They were an integral part of my university experience and continue to be a pivotal reason for doing the work that I choose to do.

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Grandpa and Grandma, this thesis is for you. I miss you every day. All of this hard work, I dedicate to you. Thank you for everything. I love you.

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List of Acronyms

ACDU	Abbotsford Community Dialysis Unit
CDU	Community Dialysis Unit
CESD-R	Center for Epidemiologic Studies Depression Scale Revised
eGFR	Estimated Glomerular Filtration Rate
FHA	Fraser Health Authority
HD	Hemodialysis
ICF	International Classification of Functioning, Disability, and Health
IQR	Interquartile Range
NCDU	Newton Community Dialysis Unit
PASE	Physical Activity Scale for the Elderly
PCDU	Panorama Community Dialysis Unit
RCCDU	Royal City Centre Community Dialysis Unit
RPE	Rate of Perceived Exertion
SD	Standard Deviation
TCDU	Tri-Cities Community Dialysis Unit
VO2 max	Maximal Oxygen Uptake

Chapter 1.

Introduction

One in 10 Canadians has chronic kidney disease[1]. Globally, the prevalence and burden of chronic kidney disease continues to increase[2]. The number of Canadians receiving dialysis treatment for end-stage kidney disease has more than tripled over the past twenty years[1]. In addition to the substantial financial burden of dialysis treatment on the Canadian health care system, dialysis patients personally experience significant physical and psychological burdens. Dialysis patients have poorer health outcomes as compared to people without end-stage kidney disease, including: lower functional status and physical functioning[3,4], higher mortality rates[5], reduced quality of life[6,7], higher risk of falls[8–13], and an increased likelihood of experiencing symptoms of depression[14,15]. It is integral, therefore, to develop effective interventions to improve the health of dialysis patients. Exercise has been well-researched as a feasible intervention to offset the poor physical and mental health outcomes in this population[16–18]. However, despite the extensive body of literature investigating exercise for dialysis patients, there is a lack of evidence on group-based exercise delivered at a dialysis unit immediately prior to hemodialysis. This thesis reports on the results of a study investigating the efficacy of, and patient and staff experiences with, a pragmatically-designed, group-based exercise program delivered prior to hemodialysis.

1.1. Chronic Kidney Disease and Dialysis

1.1.1. Pathophysiology

Chronic kidney disease is defined by the prolonged presence (> 3 months) of abnormalities with kidney function or structure[2]. It is commonly diagnosed through blood tests to estimate glomerular filtration rate (eGFR), urine tests to explore irregularities in urine sediments, imaging tests (e.g., ultrasounds) to assess structure and size, and/or biopsies to verify signs of kidney disease or infection[19]. Although the specific etiology of chronic kidney disease remains unclear for many patients, diabetes and hypertension are the two most commonly reported causes[2]. Other conditions associated with chronic

kidney disease include reoccurring kidney infections, inflammation of glomeruli (glomerulonephritis) or other kidney structures, polycystic kidney disease, acute kidney injury, and autoimmune diseases[16,20]. The progressive development of chronic kidney disease is also associated with other genetic and acquired risk factors such as smoking, obesity, family history, and older age[21]. Chronic kidney disease is classified into 5 stages based on markers of eGFR, and kidney damage identified by pathologic abnormalities[22]. In the initial stages of chronic kidney disease, medication and lifestyle changes (e.g., dietary adaptations, smoking cessation, exercise, blood pressure, and diabetic control) may be implemented to try to manage the disease's progression[23]. The final stage of chronic kidney disease, stage 5, also known as end-stage renal disease, requires renal replacement therapy in the form of dialysis or kidney transplant in order to sustain life.

1.1.2. End-Stage Renal Disease Treatment

Hemodialysis, peritoneal dialysis, and renal transplantation are the only options to treat end-stage renal disease. The Kidney Foundation of Canada reports that in 2017, approximately 28,000 Canadians were receiving a form of dialysis, the most common treatment for kidney failure[1]. During hemodialysis (HD), a patient's blood is filtered by an external HD machine, which removes waste products and excess fluid before it returns the blood to the body[24]. There are three types of vascular access to the patient's body: a central venous catheter, arteriovenous fistula, or arteriovenous graft. HD may be delivered at an in-centre unit (i.e., hospital-based dialysis unit or community-based satellite unit) or conducted by patients in their own homes (i.e., home hemodialysis). A common HD treatment schedule includes thrice-weekly treatments at an in-centre unit, lasting 3-5 hours each. However, HD schedules can vary greatly. Home HD patients may have the opportunity to dialyze more frequently, such as nightly nocturnal treatments. Some in-centre HD patients may also require HD treatments more or less frequently than the typical thrice-weekly schedule, depending on individual requirements. In contrast to HD, peritoneal dialysis functions by delivering a dialysis solution into the peritoneal cavity through a permanently affixed abdominal catheter. The peritoneal membrane filters waste and excess fluid, which are removed when the dialysis solution is emptied and exchanged. Finally, renal transplantation involves surgically transplanting a healthy, compatibility-tested kidney into the body of the end-stage renal disease patient. The five-year survival rate is 82% and 92% for patients receiving a kidney from a

deceased donor, or a living donor, respectively[1]. Wait lists for kidney transplantation are long in Canada. Further, not every patient with end-stage renal disease is eligible for a kidney transplantation due to the presence of certain comorbidities or contraindications. In 2017, more than 3,000 Canadians were waiting for a kidney[1].

1.1.3. Community Dialysis (Satellite) Unit Hemodialysis Patients

Some HD patients are eligible for, and opt to receive, dialysis at community-based (satellite) in-centre HD units. These community-based satellite units are associated with, but are physically separate from, hospital-based, full-service in-centre HD units. In British Columbia, Community Dialysis Units (CDUs) offer an opportunity for eligible HD patients to dialyze at the community-based satellite sites, "thereby freeing up the more resource intensive in-centre spaces for patients with highly complex medical and care needs"[25]. Acuity level (based on specific criteria such as blood pressure, cardiac status, fluid management, independence, individual needs, etc.), and patient-specific requirements are considered in the decision to refer a patient to receive HD at a CDU. Although the average acuity level of HD patients receiving care in a CDU may be less than HD patients who dialyze at hospital-based HD units, CDU patients still exhibit the same health concerns identified in the previous sections, and community-based satellite HD patients display similar demographic, comorbidity, and laboratory traits as hospital in-centre patients[26].

1.2. Health of Hemodialysis Patients

Broadly, HD patients experience a wide range of individual health concerns. The World Health Organization's International Classification of Functioning, Disability, and Health (ICF) framework, a classification tool for measuring health and disability for individuals and populations, provides a useful outline for discussing the health of people living on HD[27]. The framework explores functioning, health, and disability from the perspective of physiology (*body functions and structures*), the whole person (*activity*), and the whole person within the conditions of society (*participation*). End-stage renal disease, within the context of additional personal and environmental factors, affects body functions and structures, activity, and participation, which also impact each other. The ultimate result of the interactions between all of these components forms the level of

functioning and disability for an individual. The health challenges highlighted in the following sections of this thesis represent commonly identified outcomes with end-stage renal disease.

1.2.1. Physical Functioning of Hemodialysis Patients

Within the ICF framework, physical functioning can be defined as an element of health-related fitness that classifies one's ability to participate in the activities required to maintain normal mental, social, physical, and emotional function[27,28]. Physical function assessments may be conducted as laboratory-based tests of body function (e.g., peak aerobic capacity determined via a graded maximum treadmill test, VO_2max test), field-based tests of activity capacity and performance (e.g., gait speed, sit-to-stand test), or by using self-report questionnaires to assess activity participation (e.g., physical functioning scales, activities of daily living questionnaires)[28–30] . The initiation of HD can be associated with a substantial and continuous decline in functional status (defined as the ability to perform activities of daily living such as toileting, bathing, walking, and dressing)[3]. In general, laboratory-tested physical functioning and exercise capacity (VO2 max) is lower in HD patients as compared to age-matched non-dialysis patients and healthy sedentary controls[31,32]. Similarly, low scores for HD patients as compared to age-matched healthy individuals have been demonstrated in physical performance field-based gait speed and sit-to-stand tests[33]. These observed limitations in clinically-assessed function may also translate to other consequences for people living on HD. Gait speeds slower than 1.0m/s are associated with higher odds of hospitalization amongst people on HD[34]. Additionally, loss of physical functioning and requiring help with daily tasks (measured as self-reported functional dependence) is strongly associated with increased mortality for HD patients[35].

1.2.2. Falls and Hemodialysis Patients

Performance-based measures of physical functioning are also strong predictors of the risk of falls and severe fall-related injuries (e.g., hip fractures)[36,37]. With the aforementioned physical functioning limitations experienced by people living on HD, it follows, therefore, that HD patients have a higher risk of falls than non-HD individuals, and severe consequences from falls are common (e.g., fractures, death)[8–13]. HD patients exhibit the typical fall risk factors that are present in the general community, such as

older age, and they also have a high prevalence of certain disease-related risk factors, including nutritional deficiencies, muscle wasting, depression, and the use of psychotropic medications[8,10,13]. In addition, HD patients have treatment-specific risk factors, such as blood pressure and blood volume changes, that increase the risk of falls and fall-related injuries[13]. Moreover, HD patients exhibit impaired balance control and greater postural sway than age-, gender- and body mass index-matched populations, which is hypothesized to further increase the risk of falls for HD patients[38].

1.2.3. Frailty and Hemodialysis Patients

Frailty is another strong and independent predictor of the risk of falls for people living on HD[39]. Fried et al. developed a phenotype of frailty to establish a definition of frailty as a "clinical syndrome in which three or more of the following criteria were present: unintentional weight loss (10 lbs in past year), self-reported exhaustion, weakness (grip strength), slow walking speed, and low physical activity"[40]. In a large study investigating frailty among hemodialysis patients, Johansen et al. found that 230 of the 727 (31.6%) participants included in the analysis had 3 or more of Fried et al.'s frailty components (unintentional weight loss, exhaustion, low physical activity, weak grip strength, and slow gait speed)[41]. They also determined that two of the components of frailty, gait speed and physical activity, decline over time in this population. In another study, Johansen et al. conclude that frailty is very common among dialysis patients and is associated with adverse outcomes, such as being hospitalized or dying[42]. McAdams-DeMarco et al. support this conclusion by purporting that frailty can independently predict mortality and number of hospitalizations"[43]. They also suggest that frailty is highly prevalent among HD patients, 5 times more prevalent than among community-dwelling older adults.

1.2.4. Depression and Hemodialysis Patients

In addition to physical limitations, falls, and frailty, people living on HD also experience mental health challenges. Although reported prevalence varies between studies, depression rates in dialysis populations appear higher than those in the broader community. Canadian sources report a lifetime prevalence rate of 11.3% for major depressive disorder in the general community[44,45]. A systematic review reported a summary prevalence of depression amongst people on dialysis of 22.8% (assessed by

clinical interview) and 39.3% (determined by self- or clinician-administered rating scales)[46]. However, the prevalence of depression symptoms in individual HD studies varies substantially, likely due to the variability in the way depression is measured[46,47]. The proposed increased prevalence of depression amongst people living on dialysis may, in part, be due to the psychological burden associated with managing chronic kidney disease and the reliance on HD. In fact, depression is the most common psychiatric-based condition for end-stage kidney disease patients[14]. Depression in HD patients is a significant predictor of mortality[47,48].

1.2.5. Quality of Life for Hemodialysis Patients

Depression in HD patients is also correlated with low self-reported health-related quality of life[49,50]. When compared with age-matched healthy individuals, patients living with end-stage renal disease report a reduced quality of life[51,52]. Health-related quality of life incorporates physical, psychological, and social components of health[53]. The physiological and psychological burden associated with managing end-stage renal disease and HD treatment, as well as any comorbidities, can negatively impact health-related quality of life for HD patients[54]. Personal, disease-related, demographic, health system-related, or socioeconomic factors (e.g., age, sex, multiple comorbidities, education level) may further impact quality of life[55]. At the level of the whole person, low quality of life is associated with a reduced ability to perform activities of daily living, which can be highly dependent on the individual's subjective lived experience[53]. Evaluating quality of life provides valuable insights on health care effectiveness and quality, perceived health, and sense of wellbeing[53,56]. Quality of life measures can also be used to predict morbidity and mortality in HD patients[56]. Low health-related quality of life is strongly associated with a higher risk of death and hospitalization for HD patients[49,50].

1.2.6. Health of Hemodialysis Patients Summary

In general, due to multiple causes, HD patients have a high risk of hospitalization[57]. The most common reasons for hospitalization include infections related to dialysis treatment, diabetes, cardiovascular disease and kidney disease[58,59]. Additionally, mortality among end-stage renal disease patients is high[60], with many dialysis patients realizing a greater probability of death compared with several common

cancers[61]. Overall, end-stage renal disease, personal factors, and the social and cultural environment can all impact body functions and structures, leading to restrictions in an individual's activities (e.g., limitations in performing activities of daily living). The resulting health outcomes and limitations form the level of functioning and disability, which, as outlined by the evidence presented in the preceding sections, is often substantially reduced in some people living on HD.

1.3. Exercise and Hemodialysis Patients

With the abundance of health challenges experienced by patients living on HD, interventions to improve the health outcomes of HD patients are integral. In the literature, exercise is a prominent intervention that has been widely demonstrated to offset poor health outcomes in this population.

1.3.1. Health Benefits of Exercise for Hemodialysis Patients

A Cochrane systematic review on exercise training for adults with chronic kidney disease concluded that there is evidence for significant benefits of regular exercise on several of the aforementioned health concerns, including improving measures of physical fitness and functioning, cardiovascular health, and health-related quality of life[16]. Exercise training among the HD population has been shown to improve muscle quality[62] and strength[63], cardiovascular function[64–66], physical and functional performance[67–72], perceived quality of life[56,71,73,74], and balance[69,75]. Furthermore, exercise training in persons receiving HD has been demonstrated to reduce falls risk[9], hospital usage[76], and depression[67,68,74]. The literature reports on benefits from numerous exercise programs that are delivered either intra-dialytically (i.e., while the patient is connected to the dialysis machine)[73,77–79] or inter-dialytically (i.e., typically on days when the patient is not at the dialysis centre)[65,80,81]. In addition to statistically-significant changes in outcomes, exercise can also lead to meaningful changes at a clinical- and individual-level[16,17,30,54,82,83]. This is an important distinction to acknowledge because statistical significance does not necessarily imply clinical significance.

The frequency, intensity, time, and type of exercise required to impact health outcomes varies depending on the intended primary or secondary outcome[16]. The Cochrane systematic review, in which, the majority of the studies focussed on dialysis

patients, reports that the most common type of intervention was aerobic exercise, followed by a combination of aerobic and resistance exercise, and resistance exercise alone[16]. The majority of the included studies implemented high-intensity exercise interventions, with a frequency of three or five times per week, and a duration of 30 to 60 minutes per session. In addition to the randomized controlled trials included in the Cochrane review, other HD exercise studies vary greatly in the reported study outcomes and the frequency, intensity, time, and type of the exercise interventions. However, the overarching conclusion that can be drawn from the literature is that exercise can be used to help offset some poor health outcomes experienced by people living on HD[84].

1.3.2. Participation in Exercise Programs among Hemodialysis Patients

As a result of the extensive body of literature, it is widely accepted that exercise can improve mental and physical health outcomes of HD patients. The Dialysis Outcomes and Practice Patterns Study (DOPPS) provides strong evidence on the benefits of exercise outside of the research context, and reports that the odds of a patient exercising are significantly increased if a dialysis unit offers an exercise program[85]. However, many of the exercise interventions from the research literature are not sustained as a part of routine care. In fact, in their article on sustaining HD exercise programs, Bennett et al. purport that there is limited evidence of research sites maintaining exercise interventions (intra-dialytic or inter-dialytic) in real-world settings after research has concluded[86]. Other sources also report that exercise programs are not common in most HD facilities[87,88]. It follows, therefore, that despite the benefits of exercise for this population, HD patients continue to have low levels of physical activity and participation in exercise programs, in general[4,72,89]. Overall, HD patients are less active, even when compared to *sedentary* healthy controls[90]. Physical activity levels also decline over time spent on dialysis, likely due to health-related reasons such as kidney disease-specific health factors, and HD effects[85]. Other participant-reported barriers to physical activity and exercise include fatigue, shortness of breath, lack of motivation, pain, and lack of time[91,92]. It is also widely published that the exercise capacity of HD patients is low, reportedly 60 to 70% of the levels reported in age-matched populations[4,66,93]. The low exercise capacity is proposed to be due to numerous contributors, such as anemia, deconditioning, and dysfunction in the ability to deliver and/or extract oxygen by skeletal muscles.

1.3.3. Exercise Program Implementation Barriers and Facilitators

There are also barriers and facilitators to the implementation of exercise programs from the perspective of HD units. In Ontario, Ma et al. reported that only 9% of dialysis facilities had ongoing clinical exercise programs[94]. The most common facility-reported barriers to offering an exercise program included a lack of human resources, funding, and equipment. In a qualitative study on patient and staff perceptions about intra-dialytic exercise, staff workload and lack of time were the most frequently cited barriers[95]. Intra-dialytic exercise programs experience the challenge of the exercises possibly interfering with nursing care and the HD process. Constraints on available space in the HD treatment area, and the challenge of introducing exercise personnel into a busy clinical environment when conducting an intra-dialytic exercise program pose additional barriers[96–98]. Inter-dialytic exercise programs remove the patient- and facility-level barriers of incorporating exercise into the HD treatment process; however, they exacerbate the barrier of lack of time to attend an exercise program outside of dialysis.

Two studies compared the benefits of inter- and intra-dialytic exercise programs and found that, while patients who participated in inter-dialytic programs seemed to have better outcomes, they also had lower rates of adherence than patients who exercised during their regularly scheduled dialysis sessions, and the dropout rates were higher[32,99]. Although intra-dialytic programs may have higher adherence rates, the possible set of exercises is limited to activities that will not interrupt vascular access and the HD process. Additionally, for intra-dialytic exercise, some patients also find it overwhelming or stressful to receive HD and exercise at the same time, even though they may be physically able to exercise[91,97]. In contrast, inter-dialytic programs can incorporate whole-body exercise training, including use of the arms and weight-bearing exercises, but they have lower adherence and higher dropout rates as they require patients to complete the exercises on their own time on non-dialysis days[99].

1.3.4. Opportunities for Implementing a Sustainable Exercise Program

Offering an exercise program at the dialysis unit immediately prior to an HD appointment offers an opportunity to combine the advantages of both intra- and inter-dialytic exercise programs. An exercise program delivered immediately prior to HD integrates the transportation, location, and adherence benefits of an intra-dialytic

program since it is conducted at the HD unit where the participants are already present, and medical support is available, if needed. It also incorporates the benefits of an inter-dialytic program by including exercises that are not possible to perform when connected to HD machines (e.g., standing balance exercises), since participants can move freely before they are connected to the machines (pre-dialysis). Furthermore, patients may arrive early to their HD sessions and have to wait before they are connected to an HD machine. This time period provides an opportunity to implement an exercise intervention prior to dialysis while also delivering an added benefit of offering entertainment during a time when patients may normally be waiting and may be anxious or impatient for treatment to start[100–102]. Exercise programs such as these that are offered immediately prior to dialysis may be easier for units to implement and more easily transferred to other units than intra- or inter-dialytic exercise programs since they are supported by, and located at the unit, but are designed to not interfere with the HD process.

To support sustainability, Bohm et al. highlighted a potential opportunity to reduce the aforementioned facility-level financial barriers for implementing an exercise program. They proposed that exercise programs with fewer resource requirements should be considered in contrast to the potentially cost-prohibitive or impractical exercise interventions that are commonly assessed in research studies, in order to support more routine implementation of HD exercise programs[103]. An exercise program offered prior to dialysis can be conducted in a group, since participants are not connected to their HD machines and can gather in one place. In turn, the staff workload, and thus the financial cost and resources, required to deliver the exercise program may be reduced. Offering a lower intensity exercise program, in particular, also offers an additional opportunity to decrease staffing requirements and increase the translation of the research exercise program into routine clinical practice, by reducing high monitoring needs, which are common in many studies[32,104]. In fact, Bohm et al. confirm that programs involving low-intensity exercises can be incorporated into the usual HD unit environment, and can still provide benefits without requiring significant additional resources and monitoring[103]. Their study also acknowledged the importance of conducting pragmatic trials. Pragmatic studies assess the effectiveness of exercise programs in routine practice conditions, rather than investigating whether an intervention works under ideal conditions[105]. Pragmatic trials aim to produce generalizable results that are applicable in routine practice environments. Investigating a pragmatically-designed exercise intervention for

HD patients can potentially increase the translation of research findings into the usual HD unit environment, which is an existing challenge[106]. In summary, sustaining an HD exercise program requires involving exercise professionals, gaining commitment from the HD unit staff, ensuring the availability of adequate equipment and space, providing an engaging exercise program, addressing cost implications, adapting the exercises to the individual, offering an exercise program that is convenient (e.g., at the HD unit) to increase adherence, and recognizing that patients of all ages can exercise[86].

1.3.5. Exercise Research Gaps

There is a lack of evidence on exercise delivered exclusively prior to HD. In a 2005 systematic review of clinical trials of exercise training for patients receiving maintenance HD, none of the included studies investigated exercise conducted in the time period prior to dialysis[17]. A more recent 2017 systematic review and meta-analysis on exercise training in elderly HD patients[18] referenced very few studies that incorporated exercise prior to dialysis either as a standalone exercise intervention[107–109], or by combining exercise prior to and during dialysis (intra-dialytic)[110,111]. My own literature search of HD exercise programs revealed very few additional studies that implemented an exercise program with either all[69,104] or some component[9] delivered immediately prior to dialysis. The pre-dialysis exercise components offered in four studies[9,69,108,110,111] are not easily transferrable due to their use of possibly expensive equipment and resources, such as Nintendo's Wii Fit Virtual Reality, cycle ergometers and on-site gyms, as well as inherent challenges of delivering these exercise programs in group settings. Moreover, the studies offering a combination of both pre- and intra-dialytic exercise components experienced the challenge of integrating exercise into the HD process with the additional complexity of also monitoring participants in two different locations (e.g., on-site gym and the treatment area)[9,110,111].

Studies by Song et al.[109] and Matsufuji et al.[107] were more transferable, but the sample sizes were small (40 and 23 participants, respectively), which limits the insights that can be drawn. Matsufuji et al.'s study was also fairly resource-intensive as the exercise program was conducted in a rehabilitation-specific room at the HD unit under the supervision of physical therapist and physician. Song et al. also highlighted the need for further research into exercise interventions that are delivered in groups prior to dialysis. Thus, to promote sustainable implementation of exercise as part of routine HD

care, there is a need to develop and evaluate group-based exercise programs that can be delivered prior to dialysis in a non-specialized space with low-cost equipment. A gap in the research literature offers the opportunity to investigate a pragmatically-designed, group-based exercise program prior to dialysis that aims to reduce the financial, equipment, resource, and workload barriers for the sustained implementation of an exercise program for HD patients.

1.4. Research Objectives

This study will determine if a pragmatically-designed exercise program offered immediately prior to dialysis improves health outcomes in HD patients. Specifically, the exercise program uses the limited space and resources available in the CDU waiting rooms, has the potential to maximize health benefits by involving whole-body exercises at an appropriate intensity for HD patients, is designed to avoid interfering with the HD process by occurring when HD patients are not receiving treatment, and may promote adherence by taking place at a patient's regular HD treatment facility prior to a scheduled appointment. Since it is offered during the period when patients are at the CDU waiting to be connected to the HD machines, and was designed to not interfere with the dialysis process, our exercise program may be more easily integrated into the HD clinical environment.

The objectives of this study are:

Objective 1: To determine the effects of a 12-week thrice-weekly group-based exercise program delivered prior to hemodialysis at community dialysis units on the physical performance, mental and emotional well-being, and quality of life of HD patients;

Objective 2: To explore HD patient and staff experiences with a 12-week thrice-weekly group-based exercise program delivered prior to hemodialysis at community dialysis units.

Research Hypothesis: I hypothesized that participants who engaged in the exercise program would experience statistically significant improvements in their physical performance, mental and emotional well-being, and quality of life compared with patients who received standard care (no exercise intervention).

Chapter 2. Methods

2.1. Study Design

We completed a 12-week pragmatically-designed study, with a control group and an intervention group, investigating an exercise program delivered immediately prior to dialysis for CDU patients. Participants completed a baseline assessment and repeated the assessment after 12 weeks. The Research Ethics Boards at Simon Fraser University, Fraser Health Authority (FHA) and Queen's University approved the study. The data were collected at the 5 CDUs in FHA: Panorama Community Dialysis Unit (PCDU), Newton Community Dialysis Unit (NCDU), Abbotsford Community Dialysis Unit (ACDU), Tri-Cities Community Dialysis Unit (TCDU), and Royal City Centre Community Dialysis Unit (RCCDU) between January and August 2018. All participants provided written informed consent.

2.2. Study Planning

The concept for this research project originated with a request from PCDU to the FHA Falls Prevention Team to provide fall prevention education to the CDU patients. The CDU Team Leader had noticed mobility issues and concerns with falls in their patient population. The PCDU Team Leader invited me, in my role as the FHA Falls Prevention Coordinator to speak to patients at the unit while they were sitting in the waiting area, either waiting to be taken home after their HD appointments, or waiting to start their treatments. The FHA Falls Prevention Physiotherapist had also previously attended a conference presentation on exercise for HD patients, which initiated dialogue within the Falls Prevention Team about potential opportunities. After completing a Falls Prevention Mobile Clinic[112] at PCDU, followed by 2 clinics at NCDU, the FHA Falls Prevention Physiotherapist and I met with the Team Leader and Social Worker from NCDU, and discussed options for delivering exercise at the CDUs. Since the period prior to appointments was identified as a time when patients might be sitting and waiting for their treatments, it was explored as a potential time to offer an exercise program. Intra-dialytic exercise was also discussed as a potential option; however, using the period immediately prior to treatment was selected for this project when CDU staff expressed

that there may be challenges with integrating intra-dialytic exercise into the treatment area. Moreover, to support the original concern of addressing mobility, balance, and fall-related issues among the CDU patients, we preferred an exercise program that could incorporate standing balance exercises, which would not have been possible when patients were connected to the HD machines.

The Falls Prevention Physiotherapist, Co-op Student, Manager, and I collaborated with the Team Leader and Social Worker at NCDU to apply for two grants to support this work: a FHA Seed Grant and a Kidney Foundation of Canada Allied Health Research Grant. Our team received funding from both granting agencies. The FHA Seed Grant was used to conduct a feasibility study on the exercise program at NCDU between September and December 2016. The feasibility study had a single group of patients who participated in the exercise intervention and completed pre- and post-assessments. The feasibility study assessed the recruitment process, participant attendance, and patient feedback on the exercise program. The data collected from the feasibility study led to several changes to the study protocol for the current study, including increasing the exercise period from 8 to 12 weeks, changing assessments from the Short Form Health Survey (SF-36)[113] to EQ-5D-5L[114], and from the GDS-15[115] to the CESD-R[116,117] to better suit the HD population, removing the morning exercise class option, changing the exercises to an evidence-based program, and adjusting the start time of the exercise classes to adapt to the varying arrival times of the patients.

2.3. Control Group and Intervention Group Assignment

PCDU, NCDU, and ACDU have 6 different treatment cohorts. Patients typically receive treatment on Monday/Wednesday/Friday or Tuesday/Thursday/Saturday, starting at 7:00am, 12:00pm, or 4:00pm. TCDU has 5 treatment cohorts, with no treatments at 4:00pm on Tuesday/Thursday/Saturday. RCCDU only offers Monday/Wednesday/Friday 7:00am and 12:00pm treatment options. The research team selected an allocation process that ensured that both the intervention and the control groups had participants from each set of days, in case there were meaningful differences between participants attending dialysis on Monday/Wednesday/Friday and Tuesday/Thursday/Saturday. In order to accomplish this, initially, I randomly assigned PCDU, NCDU, ACDU and TCDU into pairs. The fifth unit, RCCDU, with only two dialysis treatment cohorts (compared to five or six at the other CDUs), remained unpaired, and

acted as an additional intervention unit. Next, within each pair, I randomly assigned one set of days (Monday/Wednesday/Friday or Tuesday/Thursday/Saturday) at one of the CDUs to be a control, with the second set of days at that CDU as the intervention group. For the paired CDU, the opposite intervention and control groups (i.e., set of days) were assigned (Figure 1).

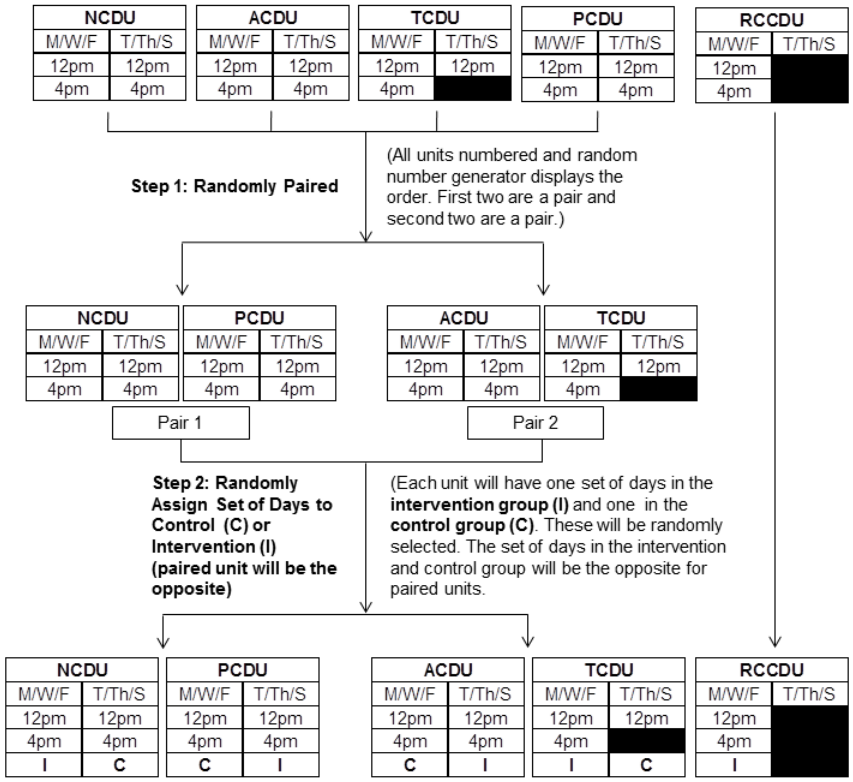


Figure 1 Unit Assignment to Control and Intervention Groups

2.4. Recruitment

Our research team consisted of a Research Coordinator (myself), a Physiotherapist who supported the exercise intervention and training, and a Co-op Student who supported the study as a Research Assistant. Prior to the start of the recruitment period, the Research Assistant or Coordinator attended a 15-minute staff meeting or staff “huddle” at each the five CDUs to provide information to staff about the study and the exercise program. CDU staff members are responsible for telling patients when their chairs are ready for their treatment to start, which would indicate the end of

the time that participants were able to exercise. Since the exercise program is delivered before patients are connected to their chairs, it was important for the CDU staff to understand the purpose of the research and the exercise intervention. The CDU staff members were not involved in the recruitment of the patients; however, the unit clerk provided the Research Assistant with a list of patients who were dialyzing on each recruitment day.

To recruit participants, the Research Assistant visited each CDU during a 2-week recruitment period and provided information about the study individually to each CDU patient during their dialysis treatment “downtime” (i.e., when the patients were sitting connected to the machines and receiving the HD treatment). If they agreed to participate, we collected written informed consent from the patients prior to baseline assessments and the start of the exercise program. We notified the CDU nephrologists via fax of their patients’ interest in the study and asked them to either provide or refuse medical clearance by signing an approval form for each patient to participate in the study.

2.5. Participant Eligibility

We recruited 55 control group and 52 intervention group participants from the 5 CDUs between January and July 2018. Patients were eligible to participate in the study if they had been receiving HD for a minimum of three months to ensure that they were in stable clinical condition, were able to walk independently for four meters with or without the use of a mobility aid, and had obtained medical clearance from their attending nephrologist to participate in the exercise program. Eligible patients from the afternoon (12:00pm) and evening (4:00pm) HD connection times were invited to participate in the research study. Morning patients at CDUs with an early connection time option (7:00am) were not included in this research study. We made this decision based on the feasibility study of this research project, during which, the morning connection time had low participation in the exercise classes (only 3 of the 10 participants exercised in more than half of the classes).

2.6. Exercise Intervention

The exercise intervention was a 12-week exercise program offered prior to the dialysis connection times. The exercise sessions were held in the CDU patient waiting areas; the sessions made use of open floor space and chairs (Figure 2). The instructors cycled through the exercises for 90 minutes prior to the typical dialysis connection times, allowing patients to start exercising whenever they arrived. This time period was selected to avoid interfering with the HD treatment. It also provided patients with the opportunity to exercise while they were waiting for their HD chairs to be ready for their treatment.

The exercise program was adapted from the Otago Exercise Program[118], a leg muscle strengthening and balance retraining exercise program originally designed for fall prevention for older adults. In the feasibility study for this research, the exercise program included a selection of 8 individual exercises, 6 of which were done while sitting. We received feedback from the feasibility study participants and directly observed that the exercise program was too easy and too short for many participants. Therefore, for this current study, the research team changed to the adapted Otago Exercise Program, an evidence-based exercise program, to increase the exercise dose and provide more targeted and progressive balance exercises. The Otago Exercise Program is designed to be moderate-intensity, but exercise capacity for HD patients is typically low,[4,93] so we created an adapted, progressive Otago Exercise Program (Appendix A) that was expected to be a suitable starting point for the CDU population.

Our adapted HD exercise program was designed to start low-intensity and progress to moderate-intensity by adding more challenging exercises as participants were able to tolerate increases. The intensity started lower by not including some of the more challenging exercises from the Otago Exercise Program at the start, and not incorporating any ankle weights initially. Participants were also asked to rate their perceived exertion following each exercise class on a scale of 1 to 10, using the Borg Cr10 Scale[119]. Throughout the 12 weeks, participants were encouraged to exercise at a 2 (weak/light) to 3 (moderate) on the Borg CR10 Scale to align with the Otago guidelines that state that “the exercises are of moderate intensity; the person should not get unduly tired[120].” Exercise intensity was progressed by introducing more challenging balance

exercises, decreasing hand support, if appropriate, and incorporating progressive use of ankle weights after the first 2 to 3 weeks, as participants were able to tolerate.

The exercise program included the 5 Otago leg muscle strengthening exercises, 6 of the balance exercises to start, with the option to progress to more challenging balance exercises, and two additional HD-specific exercises for fistula health, which are recommended by FHA and the BC Renal Agency (Appendix A). The set of exercises was expected to take approximately 20 minutes to complete, and participants were encouraged to complete at least one set of exercises. The instructors were guided to encourage participants to do 8 to 10 quality repetitions of each exercise before fatigue as per the Otago guidelines, taking 2 to 3 seconds to lift and 4 to 5 seconds to lower, and introducing ankle weights for participants, where appropriate. Even if participants were unable to complete a whole set of exercises, they were encouraged to exercise for as long as they were willing and able to exercise. Participants were also encouraged to stay and continue to do more exercises after the first set, until their HD chairs were ready. Total minutes of exercise per session were tracked for each participant. Participants were also provided with a booklet of the exercises and were encouraged to do extra repetitions of the exercises on their own time. All exercise attendance data were tracked on a study-specific Exercise Program Attendance Form (Appendix B). During the 12-week period, the control group participants received standard care (no exercise intervention).

Figure 2 NCDU and PCDU Waiting Areas

2.6.1. Exercise Intervention Personnel

Eleven exercise instructors were trained to deliver the exercise classes at the CDUs and progress participants through the program, by adding ankle weights and more challenging exercises, as per the Otago guidelines. Prior to teaching their first class, the instructors completed a 3-hour study-specific group training session that provided information on HD, the CDU patients, the research project, and the exercise program. The training was led by me (as the Research Coordinator) and the Physiotherapist. The instructors were certified by the British Columbia Recreation and Parks Association, and four of them had participated in the research feasibility study.

To facilitate the collection of research data during the exercise sessions, the exercise instructors were also supported by student volunteers (n=17) recruited from the Department of Biomedical Physiology and Kinesiology at Simon Fraser University. The student volunteers completed a 2-hour training session prior to their first shift, during which they learned how to track participant attendance data (e.g., who attended, reasons for not attending, how long participants exercised, and how participants were feeling), and how to complete the Exercise Program Attendance Form (Appendix B) for each session. The volunteers were also trained to approach participants when they arrived at the CDU and encourage participation in the exercise program.

2.7. Measures

The baseline assessments were conducted by the Research Assistant one to two weeks prior to the start of the exercise program and the final post-assessments were completed within a week of the end of the 12-week exercise program. The pre- and post-physical assessments took approximately 5 minutes per participant and were conducted when the participant arrived at the CDU before he or she was connected to the HD machine. Participants also spent approximately 20 minutes before and after the 12-week intervention period completing the pre- and post-questionnaires with the Research Assistant during the “downtime” of the HD visit. All pre- and post-questionnaires were completed through an in-person interview, during which, the Research Assistant asked the questions and recorded participant responses. If participants were unable to understand the questions in English, interpreters were used to ask participants the questions in their first language.

2.7.1. Descriptive Measures

The participants completed a baseline, study-specific Research Participant Intake Form (Appendix C) to document basic demographic information (e.g., sex, age, time on dialysis, ethnic background, comorbidities, employment status, etc.). We also calculated body mass index (BMI) as the quotient of weight (kg) divided by the square of height (m^2). The Research Participant Intake Form was completed by recording participants' verbal responses to the questions as they were asked by the Research Assistant. Data from the Research Participant Intake Form and baseline measures of the primary outcome measures were used to describe the research population.

We also reported on frailty in our population according to Fried et al.'s[40] criteria (self-reported exhaustion, unintentional weight loss of 10 pounds or more in the previous year, low physical activity, weak grip strength, and slow gait speed), which has been previously used for HD populations[121,122]. Measures for the 5 criteria were collected using several instruments. The Research Participant Intake Form asked participants if they had "lost 10 or more pounds unintentionally in the past year". Weak grip strength was categorized if a participant was below the sex- and BMI-based grip strength cut-offs identified by Fried et al. Slow gait speed was indicated by scores slower than Fried et al.'s sex- and height-based gait speed cut-offs. Self-reported exhaustion was identified based on responding "much of the time" or "most or all of the time" to at least 1 of the following statements on the Center for Epidemiologic Studies Depression Scale Revised (CESD-R)[116,117] questionnaire: "I could not get going" and "I felt that everything I did was an effort." Low physical activity was identified if a participant was in the lowest 20% of scores based on the established population norms reported in the PASE scoring manual[123]. Frailty is indicated as having 3 or more of the criteria, "intermediate" scores are provided to participants with 2 criteria, "pre-frail" is indicated if participants have only 1 criterion present, and participants with no criteria are considered "not frail".

2.7.2. Primary Outcome Measures

The Short Physical Performance Battery (SPPB)[124], EQ-5D-5L[114], grip strength, and CESD-R[116,117] were used to explore the first research objective of determining the effects of the exercise program on the physical performance, mental and emotional well-

being, and quality of life of the CDU patients. The use of SPPB[29,63,125–127], CESD-R[128], and EQ-5D-5L[55,129,130] for the HD population is well-documented.

Physical Performance: SPPB[124] was assessed at baseline and after 12 weeks as a measure of physical performance. The SPPB consists of three components: a standing balance test, a timed 4-metre walk, and a 5 times sit-to-stand test. Each component received a score between 0 (unable) and 4 (best performance). The scores from each component were added together to obtain a total score out of 12. Additionally, the time from the 4-meter walk was used to compute gait speed, and the time to complete the 5 times sit-to-stand test was recorded, if patients were able to complete the test.

Grip strength has also been demonstrated as a good marker of physical performance[131]. Grip strength of the non-fistula arm, if applicable, was measured during the pre- and post-tests with a Jamar Plus+ Digital Hand Dynamometer. The use of grip strength as a measurement for the HD population is commonly reported[121,127,132].

Quality of Life: EQ-5D-5L is a measure of health-related quality of life[114]. The assessment consists of two components: the EQ-5D-5L descriptive system, a set of questions where respondents provide the level (from no problems to extreme/unable) of difficulty with five dimensions (mobility, self-care, usual activities, pain/discomfort, and anxiety/depression), and the EQ Visual Analogue scale (VAS), a question where respondents rate their health today on a scale from 0 (“worst health you can imagine”) to 100 (“best health you can imagine”). The EQ-5D-5L descriptive system provided a 5-digit health profile that was converted to a single index value. Our EQ-5D-5L results are presented as the EQ VAS, the EQ-5D-5L converted Index Value, and frequencies of reported problems in the five dimensions[133]. EQ-5D-5L questionnaires delivered face-to-face, by telephone, by self-completion, and with interviewers are all approved modes of administration and may be used interchangeably[134]. Our Research Assistant completed the EQ-5D-5L with participants during in-person interviews.

Depression: CESD-R is a screening test for depression and depressive disorder[117]. The questionnaire consists of 20 questions in nine different areas: sadness, loss of interest, appetite, sleep, thinking/concentration, guilt, fatigue, agitation and suicidal ideation. Participants responded with how often they have felt each element

during the past week: most or all of the time (5-7 days), occasionally (3-4 days), some or a little of the time (1-2 days) or rarely/none of the time (less than 1 day). Each question received a score from 0 (rare/no issues) to 3 (most/all the time), and the scores were added together, with the range of possible total scores from 0 to 60. Total scores equal to or greater than 16 were reported as suggestive of depression. The CESD-R can be completed by interview or self-administration[135]. Our Research Assistant completed the CESD-R with participants during in-person interviews.

Physical Activity: The participants also completed a baseline Physical Activity Scale for the Elderly (PASE)[136] questionnaire to quantify their levels of physical activity prior to the 12-week study period. Although increasing the participants' physical activity levels outside of the exercise intervention was not an explicitly intended objective of this research study, PASE was repeated following the 12-week intervention period to assess if there were any changes to the PASE scores. PASE has been previously used to describe activity levels for the HD population[137]. The PASE can be administered by interview or self-completion[138]. Our Research Assistant asked the PASE questions during in-person interviews.

2.7.3. Secondary Outcome Measures

Following the 12 weeks of the exercise program, the exercise participants, CDU staff, exercise instructors, and volunteers completed study-specific feedback surveys (Appendix D, E, F, G). The surveys asked respondents a range of questions about topics related to the exercise program, such as benefits from the exercises, disturbances to the CDU (i.e., disruptions to the normal functioning of the CDU), intensity and length of the exercises, and likelihood to participate if the program was offered again in the future. The surveys included rating-scale questions and open-ended questions. The exercise program instructors and volunteers also documented notes following each exercise class (post-class notes), and these comments were included in the qualitative data analysis.

2.8. Sample Size

When this study was conducted in 2018, there were approximately 330 patients receiving HD at the 5 FHA CDUs. Prior to our recruitment, we estimated that

approximately 205 of those patients received HD in the afternoon and evening sessions. Based on the feasibility study for this research, 55% of the patients receiving dialysis at NCDU consented to participate in the exercise program and were eligible to participate based on the same inclusion criteria. Therefore, we expected that the initial sample size of this study would be around 112 participants (0.55 x 205).

The sample size for our study represents an advance on previous research in the area. In a systematic review of 29 clinical trials of exercise programs for HD patients, 45% of the included trials had sample sizes less than 20 patients, 52% had sample sizes between 20 and 75, and only one study in the review had a sample size greater than 75[17]. The majority of these trials found a significant difference in the means of the outcome measures between groups. While there is variation in population, outcomes, and treatment between this study and those reviewed, we planned our pragmatic study to have a larger sample size than all but one study in the systematic review.

To further validate the sample size and ensure statistical power, prior to conducting the study, I completed sample size calculations for the selected assessments using the formula for comparing means of two independent groups based on providing 80% statistical power to detect clinically important differences with σ=0.05 significance level and using standard deviations from the feasibility study, if available. Based on my sample size calculations, with a sample size of roughly 50 participants in each group, I expected to possibly be able to detect a difference of clinical importance in EQ-5D-5L VAS and Index Value (although no data was available for the HD population), gait speed, grip strength, and the time for 5 times sit-to-stand, but not SPPB.

2.9. Statistical Analysis

All statistical analyses were performed using SPSS Version 25 (IBM Corp. Released 2018. IBM SPSS Statistics for Windows, Version 25.0.0.2. Armonk, NY: IBM Corp.). Comparisons between the control and intervention groups on participant baseline measurements and characteristics were conducted using *t* tests for continuous, normally-distributed variables, Mann-Whitney tests for non-normally distributed and categorical variables with more than two possible outcomes, and Chi-Square tests for binomial categorical variables. The baseline and outcome measurements were summarized as mean (standard deviation [SD]) for normally-distributed, continuous

variables, median (interquartile range [IQR]) for non-normally-distributed, continuous variables, and count [n] (percent [%]) for categorical variables. For outcome measurements, *within group* differences were analyzed with paired *t* tests for normally-distributed variables, the Wilcoxon test for non-normally distributed continuous measurements, ranks, and categorical variables with more than two groups, and McNemar's test for binomial categorical outcome variables. Adjusted *between group* comparisons for continuous data were obtained using an analysis of covariance (ANCOVA) model with post-test value of the outcome measures as the dependent variable, group (control or intervention) as the independent variable, and the pre-test value of the outcome measures as a covariate. For categorical variables, adjusted differences and p-values were calculated with logistic regression by assessing the proportion of individuals with the characteristic and adjusting for baseline differences in the pre-test proportions. To support the pragmatic nature of this study, I completed our analyses from an intention-to-treat perspective for the outcome measures. I used an alpha level of 0.05 for all analyses.

I analyzed and presented the secondary outcome feedback data as frequency distributions for questions with closed-ended, scale-based questions. I presented the participant-reported benefits and lifestyle changes and CDU staff-reported benefits feedback questions with frequencies of the reported number of times a benefit or lifestyle change was identified, which was possible due to the consistent, specific responses. For the remaining open-ended questions and qualitative topics, I reviewed open-text responses and conducted open coding line-by-line in the original data. After completing the first coding, I continued with thematic analysis by combining the original codes into overarching categories, and arrived at key themes for the various topics, which are presented in data tables with sample quotes or comments from the raw data.

Chapter 3. Results

3.1. Participant Recruitment

Of the 199 afternoon and evening HD patients present at the CDUs during the recruitment period, 186 fulfilled the eligibility criteria and were approached about the research study. A total of 107 research participants consented and started the study, 52 for the intervention group participants, and 55 for the control group (Figure 3). An additional 7 participants provided initial consent but 2 left the CDU, 4 revoked consent, and 1 lost the ability to walk before the start of the study intervention period. All interested patients received clearance from their attending nephrologists to participate in the study. During the study, 4 participants dropped out and 9 participants were lost to follow-up. An additional 2 participants provided the questionnaire portions of the post-tests (CESD-R, EQ-5D-5L, PASE, and Participant Feedback Survey) that were completed on the same day as the last exercise class, but 1 participant died and 1 participant went to the hospital before completing the physical post-test assessments (SPPB and grip strength) that were conducted immediately prior to the next HD session after the last exercise class. The partial data of these two participants were included in post-test results, where applicable.

3.2. Participant Characteristics

The participants had a mean age of 69.2 (SD: 11.9) years, were predominantly male (69.2%), with a median BMI of 25.8 (IQR: 23.5, 30.5) kg/m^2, and had been on HD for a median time of 32.0 (IQR: 14.8, 59.3) months. The majority of participants (71.0%) relied on someone else to transport them to their HD appointments, such as HandyDART, Hospital Transport, or a family member. Participants were predominantly retired (82.2%), from a non-caucasian ethnic background (67.3%), and used a language other than English as a first language (65.4%). Participants had a mean baseline gait speed of 0.78 (SD: 0.22) m/s, mean grip strength of 23.2 (8.8) kg, and 22.9% had a CESD-R score suggestive of depression. The mean SPPB score for all participants was 5.6 (2.8), and 32.7% were labelled as “Frail” according to Fried et al.’s criteria. No

differences were observed between the control and intervention groups on any baseline participant characteristics (Table 1).

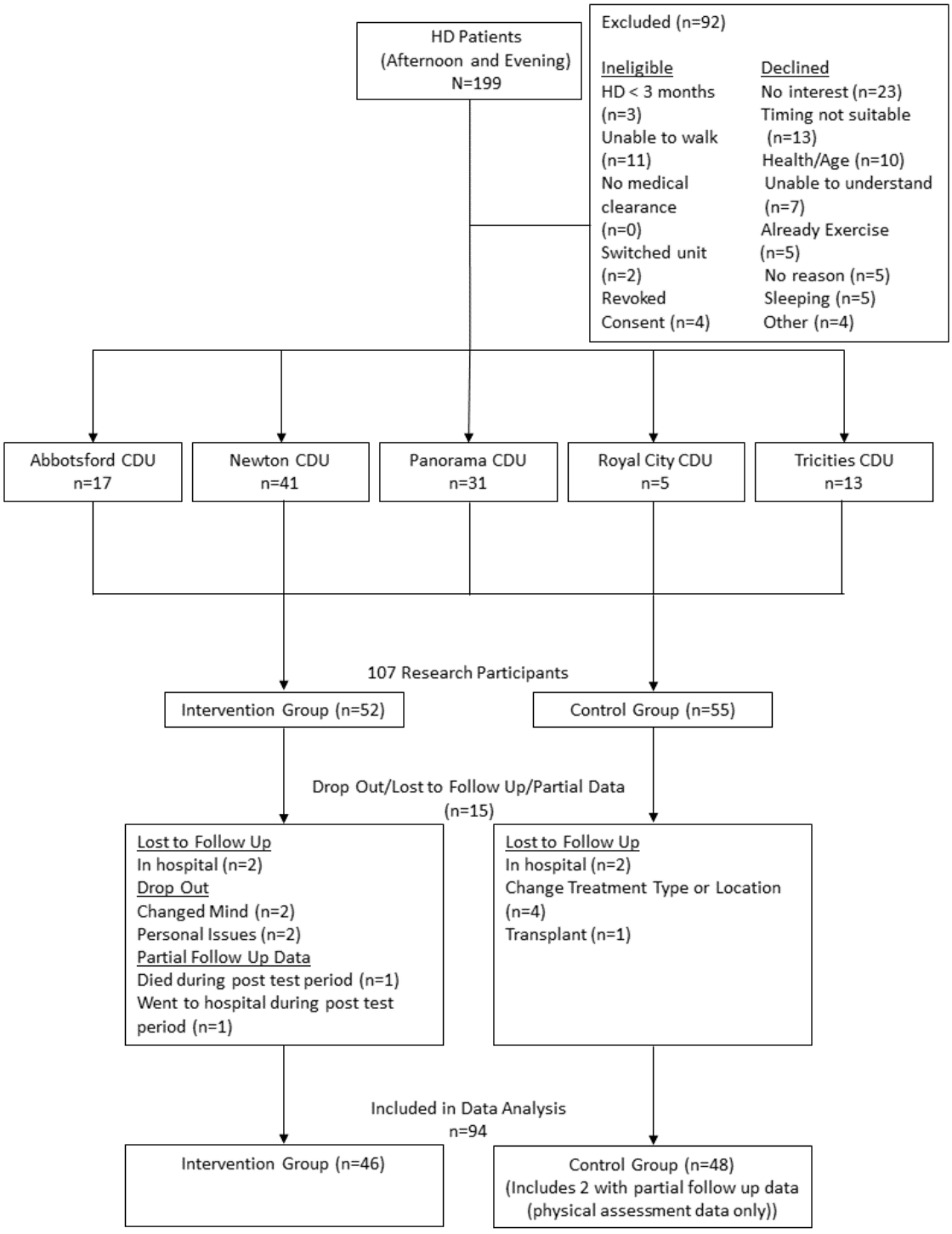


Figure 3 Participant Recruitment and Flow Diagram

Table 1 Summary of Baseline Participant Characteristics

Characteristic	Control Group (n=55)	Intervention Group (n=52)	Comparison (p-value)	Total (Overall) (n=107)
Age (years), mean (SD)	68.4 (12.3)	70.0 (11.5)	0.468	69.2 (11.9)
< 55 Years, n (%)	5 (9.1)	3 (5.8)		8 (7.5)
55-59 Years, n (%)	4 (7.3)	4 (7.7)		8 (7.5)
60-64 Years, n (%)	6 (10.9)	9 (17.3)		15 (14.0)
65-69 Years, n (%)	13 (23.6)	6 (11.5)		19 (17.8)
70-74 Years, n (%)	11 (20.0)	11 (21.2)		22 (20.6)
75-79 Years, n (%)	6 (10.9)	7 (13.5)		13 (12.1)
80-84 Years, n (%)	4 (7.3)	7 (13.5)		11 (10.3)
85+ Years, n (%)	6 (10.9)	5 (9.6)		11 (10.3)
Male Sex, n (%)	38 (69.1)	36 (69.2)	0.988	74 (69.2)
Ethnicity, n (%)				
Caucasian	21 (38.2)	14 (26.9)		35 (32.7)
South Asian	16 (29.1)	13 (25.0)	0.411	29 (27.1)
Fijian	7 (12.7)	11 (21.2)		18 (16.8)
Other	11 (20.0)	14 (26.9)		25 (23.4)
Education Level, n (%)				
Elementary or Less	10 (18.2)	12 (23.1)		22 (20.6)
Some High School	7 (12.7)	5 (9.6)		12 (11.2)
High School Grad	12 (21.8)	11 (21.2)	0.907	23 (21.5)
At Least Some Post-Secondary	26 (47.3)	24 (46.2)		50 (46.7)
Marital Status, n (%)				
Currently Married	31 (56.4)	34 (65.4)		65 (60.7)
Not Currently Married (Single, Divorced, Widowed, Separated)	24 (43.6)	18 (34.6)	0.340	42 (39.3)
Employment Status, n (%)				
Employed	1 (1.8)	4 (7.7)		5 (4.7)
Retired	43 (78.2)	45 (86.5)		88 (82.2)
Unemployed	11 (20)	3 (5.8)		14 (13.1)
English as a First Language, n (%)	21 (38.2)	16 (30.8)	0.420	37 (34.6)
First Language English	21 (38.2)	16 (30.8)		37 (34.6)
Punjabi	15 (27.3)	11 (21.2)	0.211	26 (24.3)
Hindi	4 (7.3)	11 (21.2)		15 (14.0)
Other	15 (27.3)	14 (26.9)		29 (27.1)
Transportation to Dialysis, n (%)				
Independent (Self) Transportation	14 (25.5)	17 (32.7)		31 (29.0)
Dependent (On Others) Transportation (e.g., HandyDART, Transit, Hospital Transport, Family)	41 (74.5)	35 (67.3)	0.409	76 (71.0)
Drive Self	14 (25.5)	16 (30.8)		30 (28.0)
Handy Dart	23 (41.8)	19 (36.5)		42 (39.3)
Family/Friend Drive	14 (25.5)	12 (23.1)		26 (24.3)
HandyDART/Taxi	1 (1.8)	1 (1.9)		2 (1.9)
Hospital Transfer Bus	1 (1.8)	1 (1.9)		2 (1.9)
Transit	2 (3.6)	3 (5.8)		5 (4.7)

Characteristic	Control Group (n=55)	Intervention Group (n=52)	Comparison (p-value)	Total (Overall) (n=107)
Housing Type, n (%)				
Own House	51 (92.7)	47 (90.4)		98 (91.6)
Shared Housing (Seniors Residence, Assisted Living, Other)	4 (7.3)	5 (19.6)		9 (8.4)
Time on Dialysis (months), median (IQR)	34.0 (16.0, 61.0)	31.0 (14.0, 58.0)	0.455	32.0 (14.8, 59.3)
BMI, median (IQR)	26.2 (23.5, 30.8)	25.5 (23.7, 27.8)	0.284	25.8 (23.5, 30.5)
SPPB Score*, mean (SD)	5.3 (2.8)	6.0 (2.8)	0.216	5.6 (2.8)
SPPB Total 0-3, n (%)	14 (25.5)	9 (17.3)		23 (21.5)
SPPB Total 4-6, n (%)	21 (38.2)	22 (42.3)		43 (40.2)
SPPB Total 7-9, n (%)	17 (30.9)	15(28.8)		32 (29.9)
SPPB Total 10-12, n (%)	3 (5.5)	5 (9.6)		8 (7.5)
Grip Strength (kg), mean (SD)	23.2 (8.8)	23.2 (8.8)	0.957	23.2 (8.8)
Gait Speed (m/s), mean (SD)	0.77 (0.24)	0.79 (0.20)	0.745	0.78 (0.22)
PASE, median (IQR)	37.8 (12.9, 68.5)	33.6 (13.9, 62.0)	0.741	34.8 (12.9, 65.0)
CESD-R Suggestive of Depression#, n (%)	13 (24.5)	11 (21.2)	0.681	24 (22.9)
EQ-5D-5L VAS, mean (SD)	57.1 (24.2)	64.7 (20.3)	0.091	60.7 (22.7)
EQ-5D-5L Index Value, median (IQR)	0.86 (0.78, 0.93)	0.89 (0.79, 0.95)	0.182	0.87 (0.78, 0.95)
EQ-5D-5L Mobility Problems (Problems Walking About), n (%)	26 (47.3)	22 (42.3)	0.606	48 (44.9)
EQ-5D-5L Self-Care Problems (Problems Washing or Dressing Self), n (%)	9 (16.4)	12 (23.1)	0.382	21 (19.6)
EQ-5D-5L Problems Doing Usual Activities, n (%)	21 (38.2)	13 (25.0)	0.143	34 (31.8)
EQ-5D-5L Pain or Discomfort, n (%)	29 (52.7)	23 (44.2)	0.379	52 (48.6)
EQ-5D-5L Anxious or Depressed, n (%)	17 (31.5)	12 (23.1)	0.332	29 (27.4)
Mobility Aid Use, n (%)				
Yes (Cane and/or Walker)	15 (27.3)	15 (28.8)	0.856	30 (28.0)
No (None)	40 (72.7)	37 (71.2)		77 (72.0)
Falls In Previous 12 Months, n (%)				
Yes	18 (32.7)	10 (19.2)	0.112	22 (20.6)
No	36 (65.5)	41 (78.8)		83 (77.6)
Unknown	1 (1.8)	1 (1.9)		2 (1.9)
Comorbidities, mean (SD) (Out of 11)	2.6 (1.5)	2.4 (1.2)	0.700	2.5 (1.4)
Arthritis, n (%)	19 (34.5)	16 (30.8)		35 (32.7)
Osteoporosis, n (%)	7 (12.7)	4 (7.7)		11 (10.3)
Liver Disease, n (%)	1 (1.8)	3 (5.8)		4 (3.7)
High Blood Pressure, n (%)	35 (63.6)	37 (71.2)		72 (67.2)
Lung Disease, n (%)	5 (9.1)	4 (7.7)		9 (8.4)
Heart and Cardiovascular, n (%)	22 (40)	20 (38.5)		42 (39.3)

Characteristic	Control Group (n=55)	Intervention Group (n=52)	Comparison (p-value)	Total (Overall) (n=107)
Stroke, n (%)	7 (12.7)	5 (9.6)		12 (11.2)
Peripheral Vascular Disease, n (%)	2 (3.6)	2 (3.8)		2 (3.7)
Diabetes, n (%)	28 (50.9)	30 (57.7)		58 (54.2)
Cancer, n (%)	10 (18.2)	4 (7.7)		14 (13.1)
Past Joint Replacement, n (%)	4 (7.3)	2 (3.8)		6 (5.6)
Frailty, n (%)				
Frail (3+ Fried factors present)	21 (38.2)	14 (26.9)	0.463	35 (32.7)
Intermediate (2 Fried factors present)	16 (29.1)	18 (34.6)		34 (31.8)
Pre-Frail/Not Frail (≤ 1 Fried factor present)	18 (32.7)	20 (38.5)		38 (35.5)

t tests were used for continuous, normally-distributed variables, Mann-Whitney tests for non-normally distributed and categorical variables with more than two possible outcomes, and Chi-Square tests for binomial categorical variables. *One total SPPB score is missing from the intervention group due to 1 participant declining the sit-to-stand portion of the assessment. #Two control group participants are missing a CESD-R suggestive of depression indication due to not providing responses for all questions in the assessment. The denominator used to calculate the CESD-R percentages represents total participants with valid scores. Significance testing was not completed, and therefore p-values were not reported, in instances when individual cell sample sizes were <5. BMI=Body Mass Index. SPPB=Short Physical Performance Battery. CESD-R=Center for Epidemiologic Studies Depression Scale Revised. PASE=Physical Activity Scale for the Elderly. EQ-5D-5L VAS=EQ-5D-5L Visual Analogue Scale.

3.3. Exercise Attendance

In total, the participants who completed follow-up and were included in the analysis accumulated 234.6 hours of exercise. The mean attendance at exercise classes for all the CDUs combined was 48.0% (SD: 30.4), with the lowest CDU, RCCDU, at 26.1% (13.7) and the highest CDU, ACDU, at 78.5% (20.1) (Table 2). Six research participants had HD schedules where they were only present at the unit for 1-2 classes per week. If total possible classes are used as the denominator for these 6 participants (instead of the standard 36 possible classes for all participants), the overall mean exercise attendance of possible classes is slightly higher at 49.7% (29.8). The average minutes of exercise completed per class, based on attended classes, was 17 minutes (6) for all CDUs combined. The highest average minutes of exercise completed per class was 21 minutes (7) at PCDU, with the lowest at RCCDU at 12 minutes (2). The most common reasons for not participating in the exercise classes included: chairs being ready upon arrival to the unit, not being present at the unit (e.g., in hospital, attending a different HD time, etc.), having time but not feeling well or not wanting to exercise, and being late (e.g., late HandyDART drop-off).

Table 2 Exercise Attendance Data

CDU	Measure	Exercise Class Attendance, % (Based on 36 Class Denominator)	Total Exercise Minutes Per Person	Average Exercise Minutes Completed Per Class	Average RPE*
All CDUs Combined (n=46)	Mean (SD)	48.0 (30.4)	306 (285)	17 (6)	3.1 (1.1)
	Median (IQR)	43.1 (21.5, 76.4)	227 (60, 400)	17 (12, 19)	3.0 (2.5, 3.4)
	Range	0.0, 100.0	0, 1272	8, 39	0.9, 6.0
PCDU (n=12)	Mean (SD)	46.3 (28.6)	385 (359)	21 (7)	3.1 (1.2)
	Median (IQR)	40.3 (26.4, 75.7)	254 (178, 463)	19 (17, 24)	3.1 (2.5, 3.4)
	Range	0.0, 91.7	0, 1272	13, 39	0.9, 5.9
NCDU (n=18)	Mean (SD)	43.2 (30.0)	199 (160)	13 (4)	3.3 (1.2)
	Median (IQR)	47.2 (16.0, 70.8)	157 (74, 284)	14 (10, 17)	3.0 (2.6, 3.5)
	Range	0.0, 83.3	0, 509	8, 24	1.5, 6.0
ACDU (n=4)	Mean (SD)	78.5 (20.1)	583 (365)	20 (9)	3.0 (0.8)
	Median (IQR)	77.8 (61.1, 96.5)	559 (379, 549)	20 (16, 23)	3.1 (2.2, 3.7)
	Range	61.1, 97.2	176, 1039	8, 31	2.0, 3.8
TCDU (n=7)	Mean (SD)	61.5 (35.6)	422 (291)	18 (4)	2.7 (1.2)
	Median (IQR)	75.0 (36.1, 94.4)	515 (206, 591)	19 (18, 20)	2.5 (2.1, 3.1)
	Range	2.8, 100.0	18, 830	9, 23	1.3, 5.0
RCCDU (n=5)	Mean (SD)	26.1 (13.7)	117 (66)	12 (2)	2.8 (0.4)
	Median (IQR)	22.2 (13.9, 40.3)	116 (61, 129)	12 (12, 14)	3.0 (2.5, 3.0)
	Range	13.9, 44.4	58, 220	10, 15	2.2, 3.1

*n=43 (3 participants do not have RPE data: 1 person due to language barrier and 2 people due to never exercising.)

3.4. Primary Outcomes

Mean SPPB scores were 5.40 (2.78) and 6.22 (2.70) at baseline, and 5.40 (2.74) and 6.29 (3.00) after 12 weeks for the control and intervention group, respectively (Table 3). Mean *within group* change in the SPPB scores from baseline to follow-up after 12 weeks was 0.00 (1.79) and 0.07 (1.39) for the control and intervention group, respectively, but these changes were not statistically significant (p=>0.999, p=0.737). The adjusted *between group difference* in SPPB, based on ANCOVA (control minus intervention), was -0.187 (0.339), although the change was not significantly different (p=0.583). Figure 4 shows the changes in the SPPB individual components between the pre- and post-tests. Although not significant, the mean post-test SPPB balance and sit-to-stand component scores improved for the intervention group compared to the pre-test, while the mean sit-to-stand score stayed the same for the control group, and the balance score increased slightly. The mean post-test walking scores decreased for both the intervention and control group compared to the pre-test.

The *within group* and *between group* differences for gait speed, grip strength, EQ-5D-5L VAS, and CESD-R were not significantly different between the intervention and control groups. The change in EQ-5D-5L Index Value was significantly greater (i.e., improved) for the intervention group when comparing the control group to the intervention group (adjusted *between group* difference, control minus intervention: -0.053 (0.027), p=0.048). When our exercises were included in the post-test PASE scores, the *within group* difference (compared with Wilcoxon for non-normally distributed measures) from baseline to 12 weeks was significantly higher (more physical activity) for the intervention group; however, this difference was not significant after controlling for the baseline PASE values in the calculated *between group* ANCOVA.

Table 3 Primary Outcome Results

	Control				Intervention					
Variable	**Pre-Mean (SD)**	**Post-Mean (SD)**	**Change Mean (SD)⁺**	**p-value***	**Pre-Mean (SD)**	**Post-Mean (SD)**	**Change Mean (SD)⁺**	**p – value***	**Adjusted Difference (SE)#**	**p-value#**
SPPB Score	5.40 (2.78)	5.40 (2.74)	0.00 (1.79)	>0.999	6.22 (2.70)	6.29 (3.00)	0.07 (1.39)	0.737	-0.187 (0.339)	0.583
Gait Speed	0.77 (0.24)	0.75 (0.22)	-0.02 (0.17)	0.501	0.80 (0.20)	0.77 (0.19)	-0.03 (0.14)	0.128	0.006 (0.030)	0.839
Grip Strength	23.4 (9.0)	23.1 (9.4)	-0.3 (4.7)	0.677	23.3 (8.9)	22.6 (8.6)	-0.7 (2.9)	0.122	0.422 (0.823)	0.609
EQ-5D-5L VAS	58.1 (24.0)	61.2 (23.4)	3.1 (26.2)	0.421	63.3 (20.0)	64.9 (18.5)	1.6 (21.0)	0.616	-1.8 (4.2)	0.677
Variable	**Pre-Median (IQR)**	**Post-Median (IQR)**	**Change Median (IQR)⁺**	**p-value***	**Pre-Median (IQR)**	**Post-Median (IQR)**	**Change Median (IQR)⁺**	**p-value***	**Adjusted Difference (SE)#**	**p-value#**
EQ-5D-5L Index Value	0.85 (0.72, 0.93)	0.87 (0.72, 0.95)	0.0 (-0.04, 0.08)	0.783	0.89 (0.77, 0.95)	0.90 (0.81, 0.95)	0.0 (-0.02, 0.09)	0.066	-0.053 (0.027)	0.048
PASE	36.3 (15.9, 68.9)	33.6 (25.0, 72.5)	0.0 (-22.9, 15.7)	0.795	33.6 (53.7)	32.9 (25.0, 63.4) Intervention Exercises Excluded	5.7 (-9.1, 25.0)	0.095	-5.11 (6.74)	0.451
						39.5 (30.5, 74.3) (Intervention Exercises Included)	13.3 (-6.2, 29.0)	0.004	-9.63 (6.75)	0.157

Variable	Pre-Test # Yes (%) for CESD-R Suggestive of Depression	Post-Test # Yes (%) for CESD-R Suggestive of Depression	Change, # (% Change)+	p-value*	Pre-Test # Yes (%) for CESD-R Suggestive of Depression	Post-Test # Yes (%) for CESD-R Suggestive of Depression	Change, # (% Change)+	p-value*	Odds Ratio (CI)#	p-value#
CESD-R, Suggestive of Depression	11 (24.4)	8 (17.8)	-3 (-27.3)	0.453	9 (19.6)	8 (17.4)	-1 (-11.1)	>0.999	1.21 (0.34, 4.31)	0.774

For the control group, SPPB, Gait Speed, EQ-5D-5L Index Value, and PASE scores include data for all 48 participants (n=48). Grip strength has 2 missing (n=46) due to 2 control participants being unable to squeeze the grip strength machine during post-tests (due to pain and weakness). EQ-5D-5L VAS is missing 1 person's data (n=47) because he or she did not understand the question. CESD-R (Suggestive of Depression indication) is missing 3 values due to missing responses to questions.

For the intervention group, PASE, CESD-R (Suggestive of Depression indication), and EQ-5D-5L Index Value scores include data for all 46 participants (n=46). EQ-5D-5L VAS is missing 4 intervention participants' data (n=42) because they did not understand the question. SPPB total scores are missing data from 5 intervention participants (n=41); 3 people refused the sit-to-stand portion of the test (2 during the post-test and 1 during the pre-test), and 2 people were "lost to follow-up" in between the questionnaire portion of the post-tests and the physical assessments. Grip strength is missing 3 intervention participants' data (n=43); 1 person joined the study late when the grip strength machine was not available, and 2 people were "lost to follow-up" in between the questionnaire portion of the post-tests and the physical assessments. Gait speed is missing 3 intervention values due to 1 participant being unable to complete the walking test and 2 people were "lost to follow-up" in between the questionnaire portion of the post-tests and the physical assessments.

**p-values for within group* differences are from paired *t* tests for normally-distributed variables (SPPB, gait speed, grip strength, EQ-5D-5L VAS), the Wilcoxon test for non-normally distributed continuous measurements, ranks, and categorical variables with more than two groups (PASE and EQ-5D-5L Index Value), and McNemar's test for binomial categorical outcome variables (CESD-R Suggestive of Depression indication).

#Adjusted *between group* comparisons were obtained using an analysis of covariance (ANCOVA) model with post-test value of the outcome measures as the dependent variable, group (control or intervention) as the independent variable, and the pre-test value of the outcome measures as a covariate. Adjusted differences were calculated as Control minus Intervention. Significant negative values (i.e., EQ-5D-5L Index Value difference) represent improvements. For categorical variables, adjusted difference and p-value were calculated with logistic regression by assessing the proportion of individuals with the characteristic, and adjusting for baseline differences in the pre-test proportions.

+Change means or medians were calculated by post-test minus pre-test. A positive change mean or median indicates improvement for SPPB, gait speed, grip strength, EQ-5D-5L, and PASE. A negative change is an improvement for the CESD-R Suggestive of Depression indication.

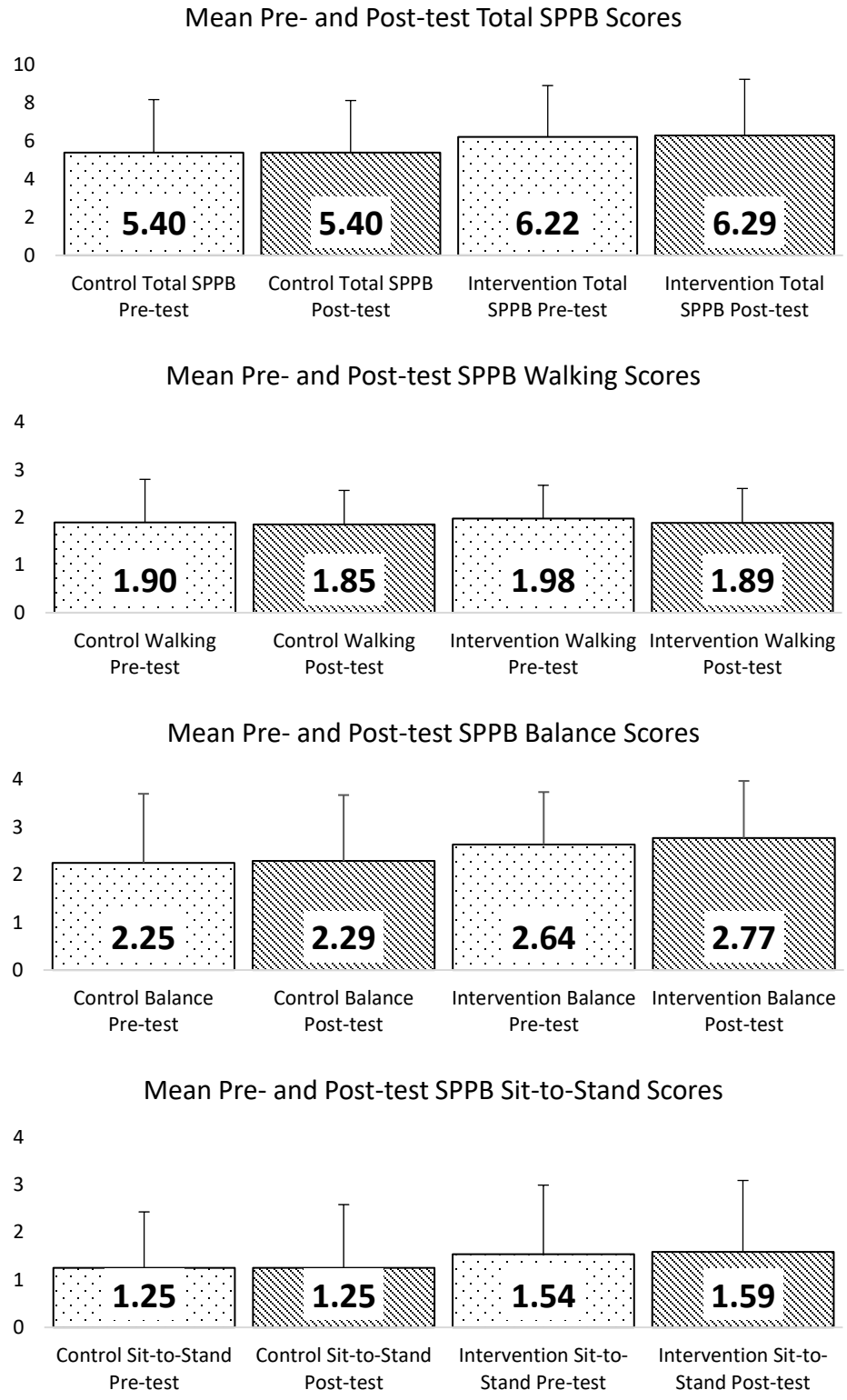


Figure 4 SPPB Score Changes Between Pre- and Post-tests

3.5. Secondary Outcomes

3.5.1. Exercise Program Feedback

3.5.1.1 Participant Feedback

Almost all (98%) of the exercise participants who completed the post-program survey (n=44) rated the exercise program as “excellent” (n=18), “very good” (n=15), or “good” (n=10). One participant rated the program as “fair” (Figure 5). Ninety-eight percent of the participants also reported that it was at least somewhat convenient to hold the exercise program before dialysis treatments. The 1 participant who indicated that it was “not very convenient” to hold the exercise program before dialysis treatment indicated on the post-program Participant Feedback Survey that they “thought it was a good program”, but, “that you should be expected to arrive at a certain time to get all the exercises in.” The participant also expressed that upon arriving at the CDU, “normally my chair is ready and if I go in right away there is less wait time and I am off earlier.” However, this participant attended 39% of the classes and concluded that “I did not go to enough of the classes, but feel it would have been beneficial”, and, “I am happy to know how to do the exercises at home now.”

Another participant expressed that having the program before dialysis was only somewhat convenient because they were “always called in early”, but, “stayed to finish the exercises despite being called in early”, even though they would have preferred to have gone to the HD treatment chair early. However, this participant also echoed many other participants’ sentiments by rating the program as “excellent” and stating that “I thought it was great to learn the exercises to do at home.” Similarly, another participant who only rated the program as “somewhat convenient” indicated that the program gave them “more energy” and they “do the program exercises at home.” The participant also indicated a desire to “rest before dialysis”, but added that they were “happy” to have learned the exercises. Two participants mentioned that they “liked that it was at the unit”, with one participant confirming that “since I am unable to drive, I am really happy the class was at the dialysis unit”. Similarly, another participant commented that they have other commitments which prevent them from exercising at any other time so “it was great” to have the class at the CDU.

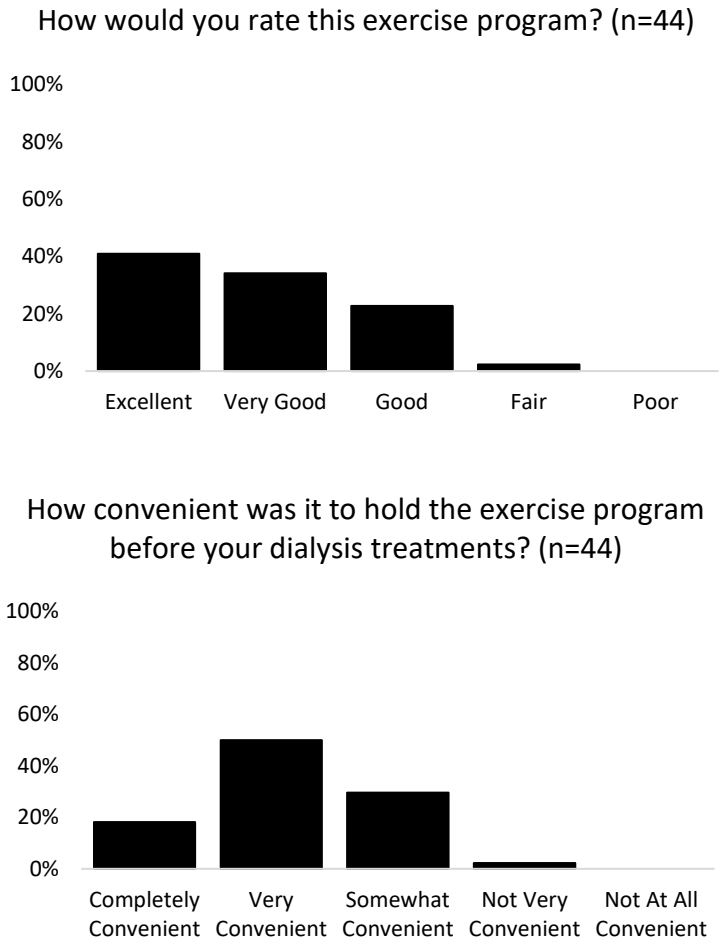


Figure 5 Participant Rating of Exercise Program

3.5.1.2 CDU Staff, Exercise Instructor, and Volunteer Feedback

Ten PCDU, 9 NCDU, 7 ACDU, and 4 TCDU staff members submitted post-program feedback surveys. All of the exercise instructors (n=11) and all of the ongoing volunteers (n=16) submitted post-program feedback surveys (excluding one volunteer who stopped volunteering after 1 month due to the small class size at ACDU). The majority of respondents (73% of CDU staff, 60% of exercise instructors, and 94% of volunteers) reported that the exercise program was “well-received by patients” (Figure 6). On the topic of patient motivation, responses were more divided; 23% (n=7) of CDU staff, 18% (n=2) of instructors, and 25% (n=4) of volunteer respondents stated they were “neutral”, and 13% (n=4) of CDU staff, 9% (n=1) of instructors, and 6% (n=1) of volunteers selected “disagree” on the question of whether “participants were generally motivated to participate in the exercise program”. However, a staff member also

commented that patients may not seek this type of exercise support elsewhere, so it was valuable to have it at the unit, removing barriers and facilitating access:

> Elderly population not likely to seek physio for themselves. It was a wonderful opportunity for physio for these patients who have limited mobility and certainly would not access physio on their own.

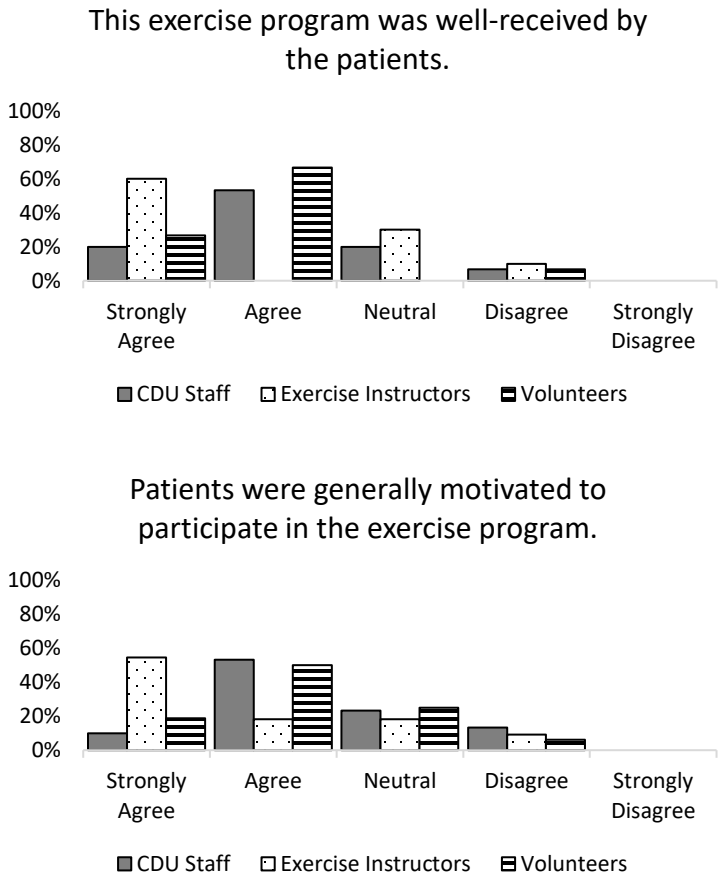


Figure 6 CDU Staff, Exercise Instructor and Volunteer General Feedback

Note: No staff feedback surveys were submitted at RCCDU. One ACDU staff member indicated "disagree" to all of the questions but did not elaborate with any comments.

CDU staff members also provided additional comments on the exercise program and their responses are included below:

> Good program with positive patient feedback.

> Instructors and volunteers were very friendly and respectful and enjoyed having them here at PCDU. From what I observed, well done and well-received.

> Great program and while not all patients are interested, the majority are and benefit from it.
>
> I think it is a great idea to offer exercise in a place that is convenient for the patients. The exercise facilitators were motivating and positive.

3.5.2. Feedback on Benefits from Exercise Program

Participants, CDU staff, exercise instructors, and volunteers were also asked about potential benefits of the exercise program.

3.5.2.1 Participant-reported Benefits and Lifestyle Changes

Forty out of the 44 exercise participants (91%) who completed a post-program questionnaire reported benefits from participating in the exercise program (Figure 7). Specifically, participants reported a range of benefits including physical benefits and mental benefits, which are summarized in Table 4. Moreover, 28 of the 44 exercise program respondents (64%) reported making lifestyle changes as a result of participating in this exercise program (Figure 7). Participants reported doing the program exercises at home as a new routine or part of an existing exercise practice, and becoming more active (Table 5).

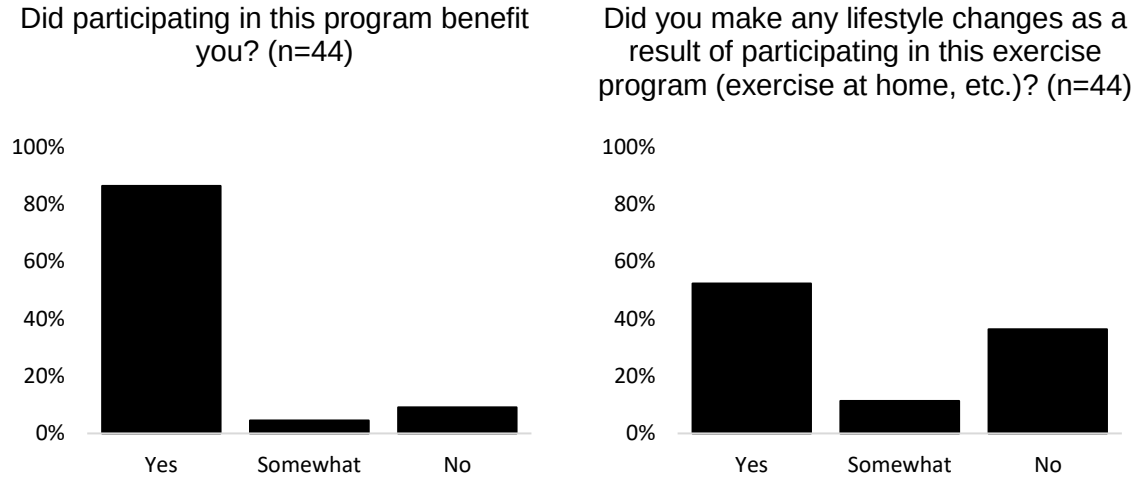


Figure 7 Participant-reported Benefits and Lifestyle Changes

Table 4 Benefits of the Exercise Program Reported by Participants

All Reported Benefits	Sample Comments from Participant Feedback Survey
Increased Energy (n=5)	[The exercise program] gives me more energy.
Learning New Exercises (n=6)	I learned about exercises [I] had never thought about before.
Strength/ Balance/ Endurance/ Physical Improvements (n=11)	Legs feel stronger. Arms feel good. Had balance problems, so found the leg exercises the most beneficial.
	Improved balance and posture. Now walking the way the instructor told [me] to. [I] had felt my posture weakening but now feel it is fixed.
	I was in a car accident and physiotherapy only took me so far. I needed to work more on my right leg to get it back to where it was before the accident. This program did that.
	Helped with walking. Can walk further now. Didn't realize how frozen my ankles were. Exercise freed them up. Increased flexibility. Good for general flexibility.
	Balance improved. Extra stretching with the instructor was really beneficial. I work a lot (70 hr/week) where I am sitting so it was good to exercise.
	Feel lighter. [I] go to Metrotown. Normally it is too much walking but *now* I do not need to take breaks.
Motivation/ Mood/ Feel Better (n=6)	For my condition, I was feeling miserable/ depressed, but exercises put me in a better situation.
	Feel good after exercise. Before was "lazy".
	Made me feel better. Got me motivated.
Increased Activity (n=4)	Got a little more active. While sitting on the couch, do leg exercises and hold hand weights.
Exercise Good For Body (n=3)	Believe exercise is good for me.
	Body has been better. Felt right. Easier for the body. Want more exercise.
Other/ Unspecified (n=5)	Good habits.
	Feel improvement.
	Less pain in legs when walking, due to exercise.

For Participant Feedback Surveys, n=44. Two participants had low participation in the exercise program (i.e., never attended) and were unable to provide feedback about the exercise program. N=4 did not report any benefits (e.g., "I feel the same and cannot tell if I have improved.").

Table 5 Lifestyle Changes from the Exercise Program Reported by Participants

All Reported Lifestyle Changes	Sample Comments from Participant Feedback Survey
Doing the Program Exercises at Home (n=16)	Started doing exercises at home.
	When I wake up, [I] do exercises, and throughout the day. Really enjoyed learning the exercises.
	While making a meal, will do heel raises and toe raises and will use fistula ball while watching TV.
Added Other Exercises to Home Routine (n=7)	Do some weights at home now.
	Using hand weights and leg weights and walk around with them at home.
More Active (n=2)	More active at home.
	Gives me more energy, which allows me to walk more.
Previously Active at Home but Incorporated Program Exercises into Routine (n=3)	Did exercises before program but now do program exercises every morning.
	Always exercise at home but like the exercises the program taught [me].

For Participant Feedback Surveys, n=44. Two participants had low participation in the exercise program (i.e., never attended) and were unable to provide feedback about the exercise program. N=16 reported no lifestyle changes (e.g., "No changes yet but want to do the exercises at home more.").

3.5.2.2 Benefits for Participants Reported by Staff, Instructors and Volunteers

When CDU staff members, exercise instructors, and volunteers were asked if the "patients experienced benefits from the exercise program", all of the volunteers, and all but one of the exercise instructors reported benefits. Conversely, 10 (34%) of the CDU staff members were "neutral" on whether their patients had experienced benefits, and 2 CDU staff (7%) did not believe that patients had experienced benefits from the exercise program (Figure 8).

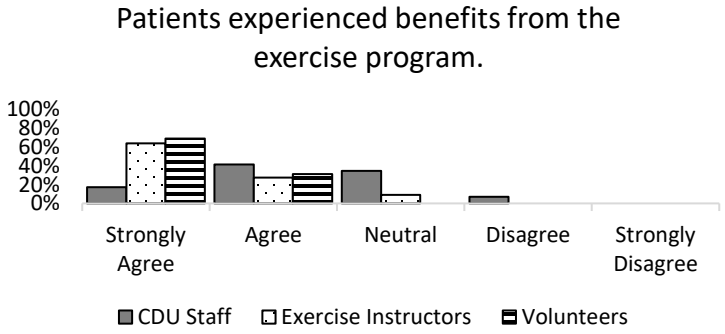


Figure 8 Benefits for Participants Reported by CDU Staff, Exercise Instructors and Volunteers

When asked to specify what benefits their patients experienced, if applicable, CDU staff members commented on several different themes including physical improvements, mood changes, well-being, and a sense of accomplishment (Table 6). An exercise instructor also commented:

> The workers I spoke to at the dialysis center felt the exercises were very beneficial to the participants.

Table 6 Benefits of the Exercise Program Reported by CDU Staff

All Reported Benefits	Sample Comments from CDU Staff Feedback Survey
Improved Mood (n=2*)	It seemed to brighten the moods of other patients.
	Increased good vibe/mood.
Well-Being (n=2)	Increased sense of well-being. Seeing possibilities for themselves as to what exercises they could do.
	I found the program to be very engaging for patients. I feel that it increased awareness of the use of light exercise to improve mobility and general well-being. Program staff were very professional and the patients seem to enjoy working with them.
Physical Improvements (E.g., Strength, Balance, Energy) (n=5*)	[For] one patient in particular, walking steadiness improved. Some appeared stronger.
	Increased mobility [and] range of motion.
	Gain exercise skills. Strength improved.
	Better circulation and helpful in walking, etc.
	Patients appear more energized.
Accomplishment (n=2)	They [the participants] appeared to have a sense of accomplishing something.
	Just noticed that patients came in early, specifically to participate in exercise program. Seemed to enjoy participating and no pressure to those who chose not to participate for the day.

*2 staff members reported benefits that were included in the totals of two different categories and counted twice (i.e., 1 staff member reported benefits in mobility, range of motion, and increased good vibe/mood, and 1 staff member reported improvements in walking steadiness and strength, and brightened moods). An additional 8 CDU staff members indicated that the participants had experienced benefits ("Strongly Agree"/"Agree"), but they did not specify details by providing comments on the benefits. N=10 CDU staff members were "Neutral" and n=2 indicated "Disagree" on whether patients experienced benefits. 1 CDU staff member left this question blank.

In addition to their responses on the post-program Feedback Surveys, in their post-class notes, instructors and volunteers regularly documented comments about additional benefits and improvements that the participants experienced. Themes were created from the numerous accounts of benefits in the post-class notes and the Feedback Surveys (Table 7).

Table 7 Benefits of the Exercise Program Reported by Instructors and Volunteers

Theme	Sample Comments from Exercise Program Instructor and Volunteer Feedback Surveys and Post-Class Notes
Accomplishment	A sense of accomplishment. They became stronger and more confident with exercises. They looked forward to us coming.(Instructor)
	During my experience with the exercise program, I noticed a lot of the participants improve in attitude and their ability to perform each movement. In the beginning the participants were nervous in performing the exercises, but by the end of the 12 weeks I noticed their confidence and improvements in form and balance. After a couple weeks they were more enthusiastic to come and workout. One participant said he tried to come earlier just to come and workout. (Volunteer)
Mental Health/Mood	I think psychologically he [a participant] benefitted….He benefitted on both sides, psychologically especially. (Instructor)
	Mental wellness improved. (More laughing and smiling) (Instructor)
	I cannot get over the step by step improvements that occurred in the 3 months that they participated in. Not only in the physical abilities, but their positive attitudes as well. The nurses started to comment on how relaxed and happy their patients seem to be after exercise. (I will leave it to the powers that be to confirm this observation). (Instructor)
	Over time their mood was better. They were more motivated to participate. They were physically more capable. (Volunteer)
Physical Improvements (e.g., Strength, Balance, Pain Reduction)	Vast improvement in balance and overall strength. (Instructor)
	[One participant] was able to spend longer- balance better, walk longer. She did exercises at home too. A lot of improvements. She wanted me to share this with [the research team] too. (Instructor)
	They found that walking and getting in and out of chairs improved. One participant felt his hip issues were helped with the exercises. (Instructor)
	It was great to see huge improvement on one participant's balance during the exercise today. He could notice the difference! (Volunteer)
	Reduction in tremors, reduction of pain from chronic injury, increased mobility and decreased reliance on walker. (Volunteer)
	Many of the patients I worked with were telling me that they felt they had more energy and more strength in their walking and completing other daily tasks. (Volunteer)
	Increased flexibility and the ability to do normal activities in daily life that were not easy beforehand (standing up from sitting, walking faster, going up stairs, walking backwards). (Volunteer)
Improved Atmosphere at Unit	More people chatting among each other. (Instructor)
	I had a great experience working with the participants. They were positive and enthusiastic. It was always a calm atmosphere filled with laughter and energy. (Instructor)
	Great last class. Lots of effort from participants. People were laughing and having a good time. Noticeable improvements from consistent participants from the start of the trial. (Volunteer)

Although not identified as a major theme, and the impact of the exercise program on dialysis-related measures was not a focus of this study, two people also noted

dialysis-related benefits from the exercise program (e.g., one volunteer noted: “one participant says dialysis goes more smoothly after exercises!”).

A potential limitation of our study is that we did not ask non-participant patients at the CDUs about their experiences with the exercise program. One instructor remarked on an additional benefit of the exercise program that may not be captured in our research data:

> I had a brief conversation with a non-participant and he said he’s doing the exercises at home. Perhaps interviewing non-participants after the program that have seen the exercise being done would be beneficial as they may be doing them at home.

A volunteer also commented that “other patients not in the program enjoyed watching and it gave them something to do”.

3.5.3. Challenges with Implementation of the Exercise Program

Implementing an exercise program into 5 busy CDUs has the potential to encounter challenges and barriers. To support the pragmatic nature of this research study, our research team tried not to change the normal functioning of the unit in order to maximize the chances that a similar program could potentially be implemented into the daily CDU routine after the research. The Feedback Surveys explored potential challenges with implementing the exercise program, including disturbances to the unit and barriers to participation.

3.5.3.1 Disturbances to Unit

To collect information on potential disruptions to the functioning of the unit, staff were asked the question “did this exercise program cause any disturbances to the unit?” on the Feedback Survey (Figure 9). Reported disturbances (i.e., disruptions to the normal functioning of the CDU) varied by unit, from the lowest at TCDU where 1 out of the 4 respondents (25%) indicated disturbances, to the highest at PCDU where half (50%) of the 10 staff respondents reported disturbances. PCDU, in particular, had space issues in the waiting area.

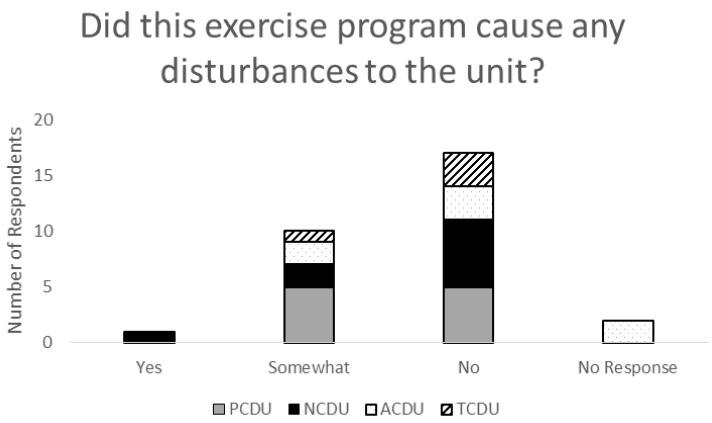


Figure 9 CDU Staff Feedback on Disturbances to Unit

Staff-reported disturbances fit into one of two themes: space, and timing of the initiation of dialysis (Table 8). Some exercise instructors and volunteers also made comments that supported the staff-reported themes, and their thoughts are included in the summary table.

Three PCDU and 2 NCDU participants also commented on space challenges and reflected that they would like a less crowded, more private space to do the exercises, while a fourth PCDU participant commented that they were fine with having the class in the waiting room. A fifth PCDU participant reported having “lots of room in the waiting room” at the time they arrived, which suggests that the waiting areas were less crowded at certain times. A final PCDU participant connected both opinions when suggesting that the “waiting room was a great place, except when it was busy with lots of people watching.”

Table 8 Disturbances to Unit from the Exercise Program Reported by CDU Staff, Exercise Instructors and Volunteers

Theme	Description	Sample Comments from CDU Staff, Volunteer and Instructor Feedback Surveys
Space	Some of the CDUs (particularly PCDU) had small waiting areas. If several patients were exercising at one time, space was sometimes an issue. PCDU resolved this issue by using the hallway as an exercise area, when needed.	At first [it was] too crowded in waiting room. Was better when moved to hall if needed and when we put more chairs in hallway to accommodate for more seating space. (PCDU staff member)
		Ran out of chairs for patients to sit. (PCDU staff member)
		Too many patients in waiting area. Unsafe to hold exercise there. (PCDU staff member)
		Space for lateral movements was limited for those that need support. (RCCDU Instructor)
		It is too bad that the only available space was the lounge. (ACDU staff member)
		I would have preferred an area separate from where we had a mix of people waiting to go in, while I am shouting 4321! (TCDU Instructor)
		Sometimes no space for other not exercising patients in the waiting room to sit. (TCDU Volunteer)
Timing/ Initiation of HD	HD chairs for the afternoon and evening sessions are ready whenever the previous patient has finished HD, which can vary. Staff call patients into the treatment area when their chairs are ready, which can sometimes occur ahead of schedule. If patients chose to do more exercises after being informed that their chairs were ready, they would finish HD later than if they went to the chair right away.	Sometimes delay HD hook-up. (PCDU staff member)
		If all patients exercising are in the same team, there would be a sudden influx of clients wanting to be on [HD] immediately. Some might have to wait longer. Some patients begin to rush to start dialysis; Some cut their treatment times to catch HandyDART. (NCDU staff member)
		It interfered with the hook-up times. (ACDU staff member)
		Delayed the HD and unit operation. (ACDU staff member)
		Some nurses had to wait to ask patients to come to their chair. (NCDU Volunteer)

3.5.3.2 Barriers to Participation

While implementing the exercise program in the CDU environment, the exercise program staff found that the variability of different factors from one class to the next created barriers or facilitators to participation (Table 9). For example, with the majority of participants relying on a form of transportation that they could not control the timing of (e.g., HandyDART), participants could not reliably choose when they would arrive at the unit. At NCDU, the HandyDART was often late for the evening group, which created a barrier to participation by limiting or removing the opportunity to exercise. The primary focus for participants was completion of their HD treatment. Therefore, if their HD chairs were available early, participants often chose to go straight to their chairs without exercising. However, arrival times and availability of chairs varied from day to day. Post-class notes from two NCDU volunteers at two consecutive classes succinctly summarize this challenge:

> Volunteer Post-Class Notes for Class # 32:
>
> Mostly everyone's chairs were ready as soon as they got here. Short exercises for the ones who exercised.
>
> Volunteer Post-Class Notes for the Next Class (Class # 33):
>
> Everyone participated well today. No one went straight to chair.

Variability of health also emerged as a common barrier to participation. Several participants were temporarily hospitalized during the research period or were present at the unit during some classes but reported not feeling well enough to exercise. Weather (from the extremes of snow, to hot, smoky summer days) was also reported as a barrier to participation. The following instructor post-class note captures the dynamic nature of the participants and the CDU unit, and the impact on exercise participation:

> One participant did not exercise (not well enough). One exercised, no weights (swelling in limbs). One participant went right in to chair. Two participants completed all exercises. One other participant went straight in. (NCDU Instructor, Instructor post-class notes)

Table 9 Barriers to Participation Reported by Instructors and Volunteers

Theme	Sample Comments from Exercise Program Instructor and Volunteer Feedback Surveys and Post-Class Notes
Reliance on HandyDART Transportation and Variability of Arrival Times	Great class. Some participants came late due to HandyDART [and were] only able to exercise for 10 min. (NCDU Volunteer)
	The participants who participated did well. Some participants came right at 5:00pm because HandyDART was late, but still exercised. (NCDU Volunteer)
	HandyDART came late at 4:55pm, but some still exercised. Great class! Lots of improvement and progression was seen today. (NCDU Volunteer)
	Participants arrived [at] different times. Exercise got good quality of time. Participants were well motivated. Happy :) (NCDU Instructor)
	HandyDART was late (did not show up by 5pm), which prevented participants from attending. (NCDU Volunteer)
Variability of Health	Few participants absent due to hospital/feeling sick. Good participation from the ones who exercised. (NCDU Volunteer)
	Those who regularly participate continue to challenge themselves, however, still some absent/not feeling well (seems to be a pattern). (NCDU Volunteer)
	Loved the group! Very energetic some days, not much other days. Only 2 people and one of them missed a lot of classes due to illness so his progression wasn't as noticeable. The other did very well, always tried hard and enjoyed it. [He/she] could have much more and benefited from it further. There were some days when [he/she] was too tired to participate. (TCDU Instructor)
Focus on Going to Chairs/ Variability of Chairs Being Ready for Treatment	Most participants were called straight to chair or not feeling well. Those who participated found exercises helpful so far. (NCDU Volunteer)
	It's been difficult to do any more than one set [of exercises] because chairs become open and people are eager to sit down. (RCCDU Instructor)
Weather	In my case, in the first two months, the participation was good but as the weather became hotter and the air filled with smoke, the participation fell off significantly. I think there would have been better participation during cooler months. (RCCDU Instructor)
	Heat seems to have influenced energy levels. (RCCDU Instructor)
	It was hot so they got tired faster. One participant said he really enjoyed these exercises and could feel his legs getting stronger.(TCDU Volunteer)
	Snow (weather) did cause some lates and absences. (NCDU Volunteer)

Adding further support to the themes identified by the exercise instructors and volunteers, the CDU participants also reported fatigue or health-related issues as the most common barrier to participation, followed by an inability to arrive at the unit early (due to transportation restrictions or other commitments), and chairs being available upon arrival at the CDU.

3.5.4. Feedback on Suitability of Exercise Program

Through the Feedback Surveys for the participants and instructors, our research team also explored whether the exercise program was suitable for the CDU patients. The participants and instructors were asked to rate the intensity and length of the exercise sessions (Figure 10). While the majority of participants (59%) rated the intensity of the exercises as “just right”, 17 of the 44 participants (39%) felt the exercises were “easy”, and 1 participant reported that the exercises were “hard”. Three of the exercise instructors reported that the exercises were “easy” for participants, 1 instructor suggested that the exercises were “easy” for some and “just right” for others, and the rest of the instructors who responded to this question (60%) reported that the exercise intensity was “just right”. The majority of the participants and the exercise instructors (89% and 70%, respectively) reported that the length of the exercise sessions was “just right”.

Some participants also suggested that the intensity varied:

> I found that the intensity of the exercises was geared to each person. Some days it was moderate for me, and some days it was light. I even broke a sweat a few times.

> The exercises started off hard [and] became just right due to practice.

> Sometimes the exercise was hard, but sometimes it was easy.

In their post-class notes and Feedback Surveys, instructors talked about progressing the intensity of the exercise program as participants wanted “to progress and do more exercises and higher intensity” exercises. Several instructors documented comments about progressing some of the participants with heavier weights, more repetitions, and more challenging exercises:

> Using the ankle weights was a great way to increase the intensity of the program and suited the exercise very well. (Instructor, Instructor Feedback Survey)

> I had to make the exercises a little harder in the last few weeks of the program by adding more weights, reps or including a few exercises for challenges. (Instructor, Instructor Feedback Survey)

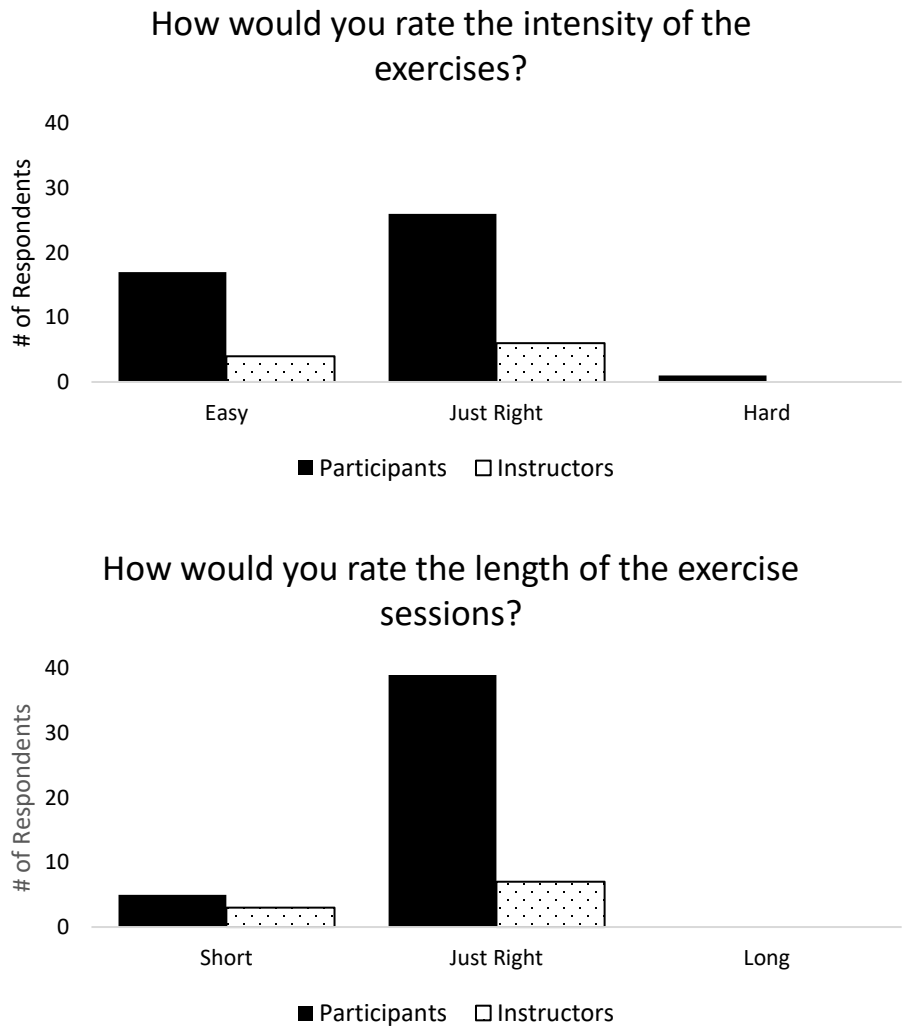


Figure 10 Participant- and Instructor-Reported Exercise Intensity and Length

On the other end of the ability spectrum, one exercise instructor also discussed adapting the exercises to a lower level for a participant who had restrictions:

> I had to add some exercises outside the format for a participant who was restricted in what she could do as per the nurses' recommendations. (Instructor, Instructor Feedback Survey)

The comments about progressions, along with the discussion of adapting the exercise program for participants who had limitations, highlighted the variability of the CDU population. Due to the pragmatic nature of our study, our inclusion criteria were fairly non-restrictive and we recruited participants with a variety of different functional levels. The exercise instructors added support to this concept by reflecting that although

some of the participants felt the exercises were too easy, others felt the exercises were appropriate:

> I feel the exercises were appropriate for the participants. (Instructor, Instructor Feedback Survey)

> A few clients felt exercises [were] too easy. (Instructor, Instructor Feedback Survey)

Furthermore, a volunteer also documented an interesting insight, which suggests that the exercises may have been more challenging for some participants than they realized:

> I noticed that when I asked patients how hard the exercises were, they always said light, but sometimes they would be sweating and be out of breath. I think they were thinking compared to other exercises other people do, not for themselves. (Volunteer, Volunteer Feedback Survey)

In summary, the exercise instructors concluded that the CDU population requires an exercise program that can be adapted and supplemented with progressions, especially if the program continues for a longer period. After completing the feasibility study and determining that the exercises were too easy and did not allow for progressions, the Otago Exercise Program was selected for this study to provide more opportunities for progressing patients. A CDU staff member commented that the instructors appeared to offer the opportunity to adapt the exercises, and the "patients seemed to really enjoy the individualized and focussed workouts". Some participants progressed quickly, and the instructors suggested implementing more exercises to continually challenge and progress participants:

> Excellent starting exercises. If program was much longer we would need more progressions. (Instructor, Instructor Feedback Survey)

> They seemed to be able to advance beyond these exercises in my opinion. Other falls prevention exercises could be progressed towards. (Instructor, Instructor Feedback Survey)

> I think the program is worthwhile, and the exercises well-suited to the candidates. When considering the exercises, I believe the basic exercise format was well-suited to most of the fitness levels and if not, a capable personal trainer would have enough flexibility with the programs to add some variations and progressions. (Instructor, Instructor Feedback Survey)

3.5.5. Recommendations for Implementing an Exercise Program at the CDUs

On the topic of continuing an exercise program at the CDUs, the exercise instructors and volunteers, CDU staff, and exercise participants were asked to provide suggestions for improvement. Their responses to this question, along with their additional comments, were analyzed to develop recommendations for future implementation. Three themes emerged from the data: consider other space options, increase inclusion of and support from CDU staff (e.g., education regarding exercise and involvement in the promotion of the program), and introduce more progressions and variety in the exercises (Table 10). The themes were reported from all four groups of respondents: exercise instructors, volunteers, participants, and CDU staff.

Even though the instructors, participants, and volunteers highlighted the need for more progressions, one instructor, who taught at RCCDU, the unit with the lowest attendance, also expressed the challenge with being able to progress participants at RCCDU:

> [I] have no issues with the exercise selections, I only wish I had a chance to "progress" the participants to more difficult exercises and/or more "sets". There was some progression but nothing significant because of the aforementioned drop in participation. (RCCDU Instructor, Instructor Feedback Survey)

Although not repeated frequently enough to emerge as a theme, one instructor suggested that creating a set time for the exercises may offer the opportunity to offer a more thorough exercise program, which was also supported by the previously documented participant quote that also mentioned arriving at a specific time to ensure time to complete all exercises:

> [Would like a] better set time (e.g., sometimes [participants would exercise for] 2 mins, sometimes 20). Could do proper program if there was a set time. Set time = time for proper program with all muscles. (NCDU Instructor, Instructor Feedback Survey)

Table 10 Recommendations for CDU Exercise Program Implementation

Theme	Sample Comments from Instructor, Participant and Staff Feedback Surveys
Consider Other Space Options	Bigger space separate from patient's waiting area. (PCDU staff member)
	Provide space [dedicated to the exercises]. (PCDU/NCDU Instructor, Instructor Feedback Survey)
	Just getting more space for the class to take place in would be perfect. Perhaps an unused office or empty meeting space would be sufficient. For example, the meeting room at the Panorama unit was almost always empty. (PCDU Volunteer)
	Space is tight. I think a certain area should have been blocked off just for this program. (NCDU participant)
Inclusion of CDU Staff/ Increased CDU Staff Support of Program	Getting support from unit was very important and needed. I would suggest for more support from staff of the unit. (PCDU/NCDU Instructor)
	Slight communication issue (e.g., staff saying they are ready early, etc.). Staff that didn't know. Consider presenting to staff ahead of time (more so?). Increase knowledge of leading staff. I would like more emphasis on exercise side of things from professionals (doctors, staff, etc.). More emphasis on importance. Should be one of the priorities. (ACDU Instructor)
	There should have been a motivational speech at the beginning of the program that explained the importance of exercise and benefits of the program to the patients. I also think it would be important to hear it from the doctor about the importance of exercise. If the doctor recommended it, then we would have had more participants. (NCDU participant)
	Provide more education about exercise to motivate the people who did not exercise. (NCDU participant)
	More education to the Renal Staff on the benefits of exercise. If more staff believed in the benefits of exercise, then it could have been better promoted. The disruption to the unit may have been more accepted. (ACDU staff member)
Increase Exercise Variety and Progression Options	Also add stretching/yoga/tubing/stretch bands. (TCDU Instructor)
	I would like there to be exercises even for disabled people so even they can participate (e.g., lots of sitting exercises) and then you could advertise to them that you have exercises just for them. I think it could be a mandatory program. (PCDU participant)
	Adding one or two new exercises to challenge participants once they have learned good technique and focus on safety. (PCDU Instructor)
	[Add] more kinds of exercises, perhaps even walking around the building. NCDU participant)
	Change up the exercises. Not always the same exercises. (NCDU participant)

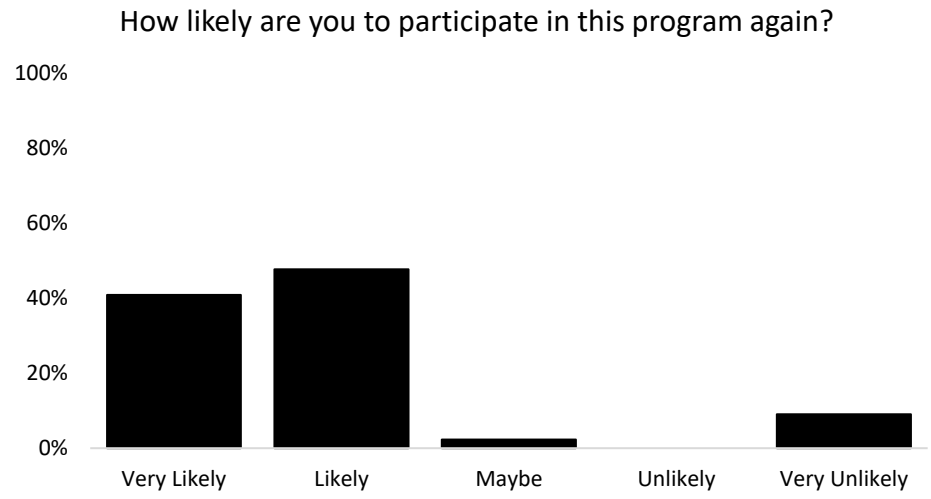


Figure 11 Participant-reported Likelihood to Participate in Exercise Program Again

Overall, 89% of the participants reported that they would participate in the program again (Figure 11). One person reported “maybe” and 4 people reported that it was “very unlikely” that they would participate in this program again.

The feedback on the exercise program was predominantly positive. During the final classes, instructors reported that participants were sad that the program was ending, and that they wanted it to come back. Many participants reported that they would like the exercise program to become permanent at the CDUs. An ACDU staff member also suggested “that it would be better received in a second round, now that others have observed.” Some participants reported that they would continue to do the exercises at home. One exercise instructor captured the sentiments of many of the numerous positive feedback comments by stating in the Instructor Feedback Survey:

> It is my deep hope that we can continue to teach a program of this nature for the patients. I know that these exercises and instructions help improve physical health as well as mental health and well-being, which is so needed by these patients. I would be happy to participate in future programs of this nature. Please do not hesitate to contact me for further information and participation.

Chapter 4. Integrated Discussion

4.1. Interpretation of Results

4.1.1. Summary of Results

Our study was one of the first research studies focussing primarily on investigating the efficacy of, and patient and staff experiences with, a pragmatically-designed exercise program (delivered immediately prior to dialysis) on physical performance, quality of life, and mental and emotional well-being. The results showed that mean pre- and post-test SPPB scores remained the same for the control group (5.40 (2.78) to 5.40 (2.74)) and increased slightly for the intervention group (6.22 (2.70) to 6.29 (3.00)) after 12 weeks, although not significantly. For the individual components of SPPB, the mean SPPB balance and sit-to-stand scores improved for the intervention group, while the mean sit-to-stand score stayed the same and the balance score increased slightly for the control group; however, these results did not reach statistical significance. When study exercises were included in the post-test PASE scores, the *within group* difference from baseline to 12 weeks was significantly higher (more physical activity) for the intervention group. The *within group* and *between group* differences for gait speed, grip strength, EQ-5D-5L VAS, and CESD-R were not significantly different between the intervention and control groups. The change in EQ-5D-5L Index Value was significantly greater for the intervention group compared to the control group (adjusted *between group* difference, control minus intervention: -0.053 (0.027), p=0.048). For the secondary outcomes, the majority of participants, CDU staff, and exercise instructors and volunteers provided positive feedback, and reported benefits from the exercise intervention.

4.1.2. Population Demographics

The HD patients in our study population had worse physical function than patients in previous studies. Compared with an assessment of 1111 patients with chronic kidney disease, our study population had lower SPPB scores, indicating lower levels of physical functioning (published mean SPPB of 8.3 (2.4) compared to our baseline score 5.6 (2.8))[127]. Nineteen percent of participants in this study by Reese et al.

had an SPPB score less than 7, and 34% had an SPPB score equal to or greater than 10; in contrast, 62% of our participants had an SPPB score less than 7, and only 7.5% had a score greater than or equal to 10. In Kaysen et al.'s study, 22% of their 375 participants had SPPB scores below 7, and 42% had scores equal to or greater than 10[125]. Interestingly, Kaysen et al. report that their participants scored lower on the SPPB than other comparison studies; however, our distribution of SPPB scores was still remarkably lower than even similarly aged renal failure, heart failure, chronic obstructive pulmonary disorder, and high cardiovascular risk populations[125]. This highlights the low functional status of our study population, which may be partially due to the pragmatic nature of our study and the relatively non-restrictive inclusion criteria. Jung et al. suggest that some studies focus on dialysis patients who are relatively healthy, young, and active, without serious comorbidities"[79]. Our study population was also considerably less active (PASE median (IQR): 34.8 (12.9, 65.0)), than both published norms of PASE data for a population of older adults (mean (SD): 102.9 (64.1))[123], and even dialysis patients (mean (SD): 90.3 (76.8)).

4.1.3. Exercise Attendance

In a Cochrane systematic review on "Exercise training for adults with chronic kidney disease", only 15 of the 45 included studies reported on adherence to the intervention[16]. All 15 studies with reported adherence had "high compliance" to the exercise interventions (reported as greater than 70% for 12 of the studies) or a combination of "moderate" and "high compliance" (between 50 to 70% for the remaining 3 studies). In our study, our average exercise attendance for all CDUs combined was 48% (30.4) (49.7% (29.8) when only possible classes are considered for participants attending HD less than thrice weekly), which is lower than any of the studies included in the review. Although the Cochrane review only considered randomized controlled trials, other studies and reviews report similarly high exercise adherence/compliance[17,62,139]. Some studies also report excluding patients from the analysis if they drop below a certain adherence to the exercise intervention, which leads to inflated reported adherence data[9,69]. Primarily, HD exercise research literature lacks frequent reporting of adherence to interventions, which leads to a lack of clarity on the appropriate dose of exercise required to impact the intended outcomes, and limited ability to compare adherence between interventions[103].

A more suitable comparison for our study may be Bohm et al.'s pragmatically designed study investigating the effects of an intra-dialytic cycling program compared to a home-based pedometry intervention[103]. Bohm et al. suggest that although their adherence rates of 53 and 52% may seem low, their rates are similar to or higher than published exercise program adherence rates for both the general population and chronic disease populations. Our pragmatic study is similar to this range. Moreover, the majority of the studies listed above, including Bohm et al.'s pragmatic study, had small sample sizes and single-unit interventions, which would serve to enhance exercise adherence. Our study demonstrates that a more complex, multi-unit pragmatic exercise program with a larger sample size can be successfully incorporated into busy clinical practice environments and still achieve reasonable exercise adherence. Additionally, we were able to increase the amount of time spent exercising per session compared to the feasibility portion of our study, which involved a shorter set of non-progressive exercises (designed to last approximately 10 minutes). Further changes to the exercise intervention, including more staff support and patient involvement in the design of the program, may further increase the attendance and amount of time spent exercising.

4.1.4. Primary Outcomes

Health-related quality of life (measured by the EQ-5D-5L Index Value) improved significantly in the intervention group relative to the control group. This result was consistent with the secondary outcome (feedback) results; participants directly reported 4 out of the 5 domains of health-related quality of life from the EQ-5D-5L questionnaire as benefits in their qualitative feedback (i.e., improvements with mobility, pain, anxiety/depression (mood), and usual activities). This improvement in health-related quality of life may not be due completely to the effect of the exercises alone. Our exercise classes introduced other potentially important non-exercise-related psychosocial components, such as social interactions with the exercise staff and other participants. Therefore, the significant change in health-related quality of life should be interpreted within the context of the entire exercise program, which included the social interactions with the exercise instructors, volunteers, and other participants. Interventions that target biological factors, as well as psychosocial factors, have been identified as important for improving quality of life for dialysis patients[49]. None of the other primary outcomes changed significantly in response to the exercise intervention.

Although much of the published HD exercise literature has demonstrated changes in the primary outcomes following an exercise intervention, there are several possible reasons why our study did not produce similar results. First, the number of pre- and post-test assessments we conducted may have influenced our ability to detect exercise-induced improvements in the majority of the primary outcome measures. Specifically, we conducted assessments once prior to, and once after, the 12 weeks of exercise. Since the health of HD patients can vary from day to day, it is possible that these single assessments did not accurately capture the changes experienced by the patients over the course of the exercise program. Participant scores were visibly impacted by their health on the assessment day, which created a source of variability in the data. De Villar et al. demonstrated high test-retest reliability of the SPPB for their population of HD patients; however, they also suggested that the younger age of the participants in their study may have increased the consistency of their testing results[140]. They also identified that even in their younger participant group, despite the high test-retest reliability, individual performance varied significantly between sessions.

Second, most of the previous HD exercise studies were explanatory trials focused on determining the efficacy of the exercise interventions under ideal conditions. There is a lack of pragmatic research exploring the effect of exercise on outcomes within a real-world clinical environment, where exercise dose and intensity are naturally more variable than in efficacy-based studies. In their pragmatically-designed study, Bohm et al. explained that the majority of published studies do not adequately report information on the intensity or dose of exercise received in the studies in order to impact the outcomes[103]. Greenwood et al. reiterated that there is a deficiency in the literature of complete reports on the applied exercise dose[106]. Our study focussed on low-intensity exercises, which although they have the potential to impact the outcomes, may take a longer time (volume per session and number of sessions) to realize a significant change[141]. Similarly, Bohm et al.'s pragmatically-designed study, which reported on low-intensity exercise, experienced similar challenges and did not demonstrate significant changes in the majority of their outcomes[103]. However, they concluded that "even low intensity exercise can provide benefits and that such programs are feasible within the confines of a regularly functioning hemodialysis unit without the need for significant additional resources".

Third, the amount of exercise completed by participants in our study may have been too little to lead to changes in the primary study outcomes. In Heiwe et al.'s Cochrane systematic review on exercise for adults with chronic kidney disease, only 5 of 34 (14.7%) studies reported a duration of less than 30 minutes per exercise session, with no studies reporting times less than 20 minutes[16]. Our average exercise minutes per session was slightly lower at 17 (6) minutes across all CDUs. Interestingly, the majority of our participants (88.6%) and instructors (70%) reported that the length of the exercise sessions was "just right". Moreover, the intervention period for our exercise program (12 weeks) was also relatively short. The majority of the studies in the Cochrane review reported a duration of 4 months or longer. During the feasibility portion of our study, the Research Assistant acknowledged that it took, "3 weeks or so to really get the participants on board". With the 12-week intervention, a quarter of the intervention period may have passed before participants settled into a routine. Some participants also experienced erratic attendance patterns. For example, some participants experienced periods of hospitalization during the intervention period and returned to exercising after being away. In other research studies, if participants left for health-related reasons, the participants were deemed lost to follow-up. In our study, if participants returned to the unit, they were invited to restart exercising, if appropriate. Therefore, even participants with gaps in participation were included in the analysis. It is also important to note that our sample size calculations determined that we may not be able to detect a difference of clinical importance in SPPB with our current sample size.

4.1.5. Patient and Staff Feedback (Secondary Outcomes)

The secondary outcome feedback data provides support for implementation of an exercise program at the CDUs. The majority of participants (91%), CDU staff (58%), exercise instructors (91%), and volunteers (100%) reported benefits for the patients, many of which may not have been able to be captured by the primary outcome assessments. This underscores the importance of collecting qualitative data to support primary outcome assessments. The feedback about the exercise program from the participants, and the exercise instructors and volunteers was generally very positive, whereas feedback from the CDU staff was more impartial. This impartiality is not unique to the staff in our study. Other studies report that HD staff may deem patients "too old"[3], and "too unwell", or "uninterested"[91] in exercise, and that staff opinions can be a "strong

demotivating factor for exercise"[106]. Therefore, increasing staff involvement in the design of exercise programs, and increasing education on the benefits of exercise are important to the future success of exercise interventions in HD units.

4.1.6. Recommendations for Exercise Program Implementation

The inclusion of staff in recommending exercises and supporting exercise programs is frequently reported as a critical component for the implementation and sustainability of an exercise program. Several sources, including the American National Kidney Foundation's Kidney Disease Outcomes Quality Initiative (KDOQI) clinical practice guidelines, suggest that all nephrology health professionals should provide advice and encouragement to help patients to participate in physical activity, as an integral component of patient care[142,143]. Although many sources report that renal staff, including nephrologists and frontline HD staff, believe their patients would benefit from increasing physical activity and exercise[87,144], barriers to healthcare providers providing exercise counseling for their patients are also prevalent[92,145]. Some staff report that a major barrier is the realization that exercise has not been incorporated as a priority in dialysis care[92].

Additionally, other studies report a widespread lack of healthcare provider awareness on the benefits of exercise and what to recommend to their patients[98]. However, in addition to educating healthcare providers on effective and appropriate exercise recommendations for HD patients, personal beliefs also need to be addressed. Some studies report barriers related to healthcare provider beliefs, such as believing that it is not their role to conduct exercise interventions[146], that patients would not be willing to discuss exercise[144], and that patients lack the motivation to exercise[147]. Remarkably, one study determined that a large majority (93%) of patients report that they may do more exercise if a health care professional provided guidance[91]. Therefore, if these barriers can be addressed, renal staff support can strengthen the implementation and sustainability of exercise programs for HD patients. It is also important to note that although nephrologists have an important role in the promotion of exercise and physical activity for their patients, involving frontline dialysis staff in any interventions is also very important since they have the most frequent contact with patients[86,91,144]. In our study, a lead staff member wrote in an email communication with our team, "in terms of happiness (QOL), those that were participating really seem to enjoy it, and that is

important as much as getting treatment". Including key staff members, such as this individual, who are passionate about incorporating exercise into the HD unit environment is an important part of implementing and sustaining an exercise program.

Lessons can also be learned from organizations that successfully maintain ongoing clinical exercise programs, such as the Manitoba Renal Program[148]. Jagannathan et al. are currently conducting a pragmatic clinical trial using the "Exercise is Medicine" framework to try and address the barriers and challenges faced by chronic kidney disease patients related to exercise[149]. The Southern Alberta Renal Program (SARP) offers intra-dialytic cycling at 5 HD units and 1 pediatric unit, along with an inter-dialytic exercise program for patients in all stages of kidney disease[76,88]. Based on the success of their ongoing programs, Parker has published many recommendations, including employing exercise professionals as an integral part of the HD unit and ensuring that the exercise interventions can be maintained and supported by the unit staff[88]. To lower costs and resource needs and promote sustainability, ensuring that the program requires minimal equipment and monitoring is also important. Our exercise program aimed to reduce the barrier of equipment resource needs by making use of the patient waiting area, ankle weights, and fistula grip balls, all readily available or low-cost components.

4.2. Limitations

A potential limitation and source of variability in our study came from the use of multiple instructors. Since there were 10 different exercise programs offered thrice weekly at 5 different CDUs, it was impossible to have the same instructor teach all of the classes. We designed the pre-study instructor training session to provide the same information to all of the instructors and provide some consistency in the exercise prescription and progression protocol. However, one of the volunteers who attended exercise sessions with different instructors noted that instructors had their own styles of motivating the patients and implementing the exercise program. The effect of the instructor on the participants, which likely varied in our study, is a limitation. For the sake of the research, we asked the instructors to remain consistent with the offered exercises in an attempt to ensure that we were comparing the effects of the same exercise program across the different sites. Although the study attempted to be pragmatic in nature, and some instructors tried to adapt the program to meet the needs and abilities

of some participants, the limited ability to adapt or expand to other exercises, which would be common in a real-world exercise program, was limited in our research study, in exchange for consistency for evaluative purposes. Providing additional ongoing support and training for instructors in a continuing clinical exercise program could help maintain program fidelity, while also expanding opportunities to explore further adaptations and progressions of the exercises.

Blinding of the Research Assistant and participants was not possible in this study. The use of unblinded assessors is common in HD exercise literature. Unblinded assessors may introduce bias in their assessments of outcome measures, particularly if the measures include subjective components. In our study, the primary and secondary outcome measures were either objective assessments (i.e., SPPB and grip strength), or participant-reported outcome measures (i.e., EQ-5D-5L, CESD-R, PASE, and feedback surveys). Therefore, the Research Assistant's knowledge of the participants' group assignments was not expected to significantly impact the results. To further reduce the possible impact of bias from an unblinded assessor, we employed a single Research Assistant to complete all testing, for consistency, and the Research Assistant followed the standardized testing protocols. The participants' knowledge of whether or not they received the exercise intervention could have impacted participant responses to the self-reported outcome measures. For example, an exercise intervention participant may have been more likely to report improvements based on an expectation that the exercises would lead to improvements. However, with the wide range of exercise attendance, the impact of positive reporting bias was not expected to significantly impact the results that were analyzed from an intention-to-treat perspective, which also included participants with no or low attendance. For instance, some intervention group participants even reported in the qualitative feedback that they felt they did not participate enough to have led to positive changes.

The selection of the SPPB as the primary assessment also introduced limitations. Since the exercises were primarily targeted to improve strength and balance, a more refined balance test with a continuous measure would have been preferable to compare small but clinically meaningful changes in balance. We selected the SPPB for the minimal amount of time required to complete it, since assessments were done prior to HD appointments and participants often arrived at the same time. The sit-to-stand portion of the SPPB was also a limitation. Although it had a continuous measure of time,

unlike the balance test, since many of the participants were unable to complete 5 times of the sit-to-stand (36% of participants during pre-tests), the time for 5 times sit-to-stand did not provide a useful measure that we could compare for all participants. Moreover, as previously mentioned, with only a single pre- and post-test, the test results were impacted by the health of the participants on the assessment day, which varied greatly.

4.3. Future Plans

Overall, there was a positive reception for exercise offered at the CDUs. In order to maximize the impact, suitability, and sustainability of the exercise program within the regular clinical environment, an exercise program needs to be accepted by the people who are directly impacted by the program (i.e., patients, families, and staff). Although our research team consulted with team leaders and social workers from the CDUs while designing the exercise program, there was no involvement from patients or other frontline CDU staff members in the development of the exercise intervention. Our research team has received a new patient-oriented planning grant to create an implementation plan for a patient-designed exercise program based on the needs and desires of the CDU HD patients. The results of this current study and the relationships and collaborations formed during the research, will form the basis for the planning process. This study was a first step in implementing a sustainable, ongoing exercise program in the CDU environment.

4.4. Conclusion

The literature indicates that HD patients can benefit from increasing exercise and physical activity. Studies have demonstrated numerous benefits from a wide range of interventions that increase exercise and/or physical activity either during dialysis or during non-dialysis periods. Despite the strong support for the positive effects of exercise for HD patients, the pragmatic knowledge base on clinical-based ongoing exercise programs is limited. This study determined the effects of a pragmatically-designed, 12-week, thrice-weekly exercise program prior to dialysis on the physical performance, mental and emotional well-being, and quality of life of HD patients, and patient and staff experiences with the exercise program. In this thesis, I provided evidence that a pragmatically-designed exercise program offered prior to dialysis may

improve the health-related quality of life for HD patients. Moreover, patients and staff have a desire for exercise to be offered at the CDUs. The results from this study will inform the future planning process for implementing an ongoing, patient-designed exercise program based on the needs and desires of the CDU HD patients.

References

1. Kidney Foundation of Canada. Facing the Facts 2019. https://www.kidney.ca/file/kidney.ca_nat/news-press-releases/Facing-The-Facts-About-Kidney-Disease-2019.pdf

2. Levin A, Tonelli M, Bonventre J, et al. Global kidney health 2017 and beyond: a roadmap for closing gaps in care, research, and policy. *Lancet*. 2017;390(10105):1888-1917. doi:10.1016/S0140-6736(17)30788-2

3. Kurella Tamura M, Covinsky KE, Chertow GM, Yaffe K, Landefeld CS, McCulloch CE. Functional status of elderly adults before and after initiation of dialysis. *N Engl J Med*. 2009;361(16):1539-1547. doi:10.1056/NEJMoa0904655

4. Painter P. Physical functioning in end-stage renal disease patients: update 2005. *Hemodial Int*. 2005;9(3):218-235. doi:10.1111/j.1492-7535.2005.01136.x

5. Knight EL, Ofsthun N, Teng M, Lazarus JM, Curhan GC. The association between mental health, physical function, and hemodialysis mortality. *Kidney Int*. 2003;63(5):1843-1851. doi:10.1046/j.1523-1755.2003.00931.x

6. Kimmel PL, Patel SS. Quality of life in patients with chronic kidney disease: Focus on end-stage renal disease treated with hemodialysis. *Semin Nephrol*. 2006;26(1):68-79. doi:10.1016/j.semnephrol.2005.06.015

7. Kimmel PL, Emont SL, Newmann JM, Danko H, Moss AH. Original investigation: dialysis therapy: ESRD patient quality of life: symptoms, spiritual beliefs, psychosocial factors, and ethnicity. *Am J Kidney Dis*. 2003;42(4):713-721. doi:10.1053/S0272-6386(03)00907-7

8. Cook WL, Tomlinson G, Donaldson M, et al. Falls and fall-related injuries in older dialysis patients. *Clin J Am Soc Nephrol*. 2006;1(6):1197-1204. doi:10.2215/CJN.01650506

9. Bennett P. A combined strength and balance exercise program to decrease falls risk in dialysis patients: a feasibility study. *J Exerc Physiol*. 2012;18(1):3-19. doi:10.1675/1524-4695(2008)31

10. Abdel-Rahman EM, Turgut F, Turkmen K, Balogun RA. Falls in elderly hemodialysis patients. *Qjm*. 2011;104(10):829-838. doi:10.1093/qjmed/hcr108

11. Desmet C, Beguin C, Swine C, Jadoul M. Falls in hemodialysis patients: Prospective study of incidence, risk factors, and complications. *Am J Kidney Dis*. 2005;45(1):148-153. doi:10.1053/j.ajkd.2004.09.027

12. López-Soto PJ, De Giorgi A, Senno E, et al. Renal disease and accidental falls: A review of published evidence. *BMC Nephrol*. 2015;16(1). doi:10.1186/s12882-015-0173-7

13. Rossier A, Pruijm M, Hannane D, Burnier M, Teta D. Incidence, complications and risk factors for severe falls in patients on maintenance haemodialysis. *Nephrol Dial Transplant*. 2012;27(1):352-357. doi:10.1093/ndt/gfr326

14. King-Wing Ma T, Kam-Tao Li P. Depression in dialysis patients. *Nephrology*. 2016;21(8):639-646. doi:10.1111/nep.12742

15. Finkelstein FO, Finkelstein SH. Depression in chronic dialysis patients: Assessment and treatment. *Nephrol Dial Transplant*. 2000;15(12):1911-1913. doi:10.1093/ndt/15.12.1911

16. Heiwe S, Jacobson SH. Exercise training for adults with chronic kidney disease. *Cochrane Database Syst Rev*. 2011;(10). doi:10.1002/14651858.CD003236.pub2

17. Cheema BSB, Fiatarone Singh MA. Exercise training in patients receiving maintenance hemodialysis: A systematic review of clinical trials. *Am J Nephrol*. 2005;25(4):352-364. doi:10.1159/000087184

18. Matsuzawa R, Hoshi K, Yoneki K, et al. Exercise Training in Elderly People Undergoing Hemodialysis: A Systematic Review and Meta-analysis. *Kidney Int Reports*. 2017;2(6):1096-1110. doi:10.1016/j.ekir.2017.06.008

19. Levin A, Hemmelgarn B, Culleton B, et al. Guidelines for the management of chronic kidney disease. *Cmaj*. 2008;179(11):1154-1162.

20. Jha V, Garcia-Garcia G, Iseki K, et al. Chronic kidney disease: Global dimension and perspectives. *Lancet*. 2013;382(9888):260-272. doi:10.1016/S0140-

6736(13)60687-X

21. Kazancioğlu R. Risk factors for chronic kidney disease: An update. *Kidney Int Suppl*. 2013;3(4):368-371. doi:10.1038/kisup.2013.79

22. Arora P, Vasa P, Brenner D, et al. Prevalence estimates of chronic kidney disease in Canada: Results of a nationally representative survey. *Cmaj*. 2013;185(9):417-423. doi:10.1503/cmaj.120833

23. Levey AS, Coresh J. Chronic kidney disease. *Lancet*. 2012;379(9811):165-180.

24. Moulton K. *Dialysis Programs in Canada*. Canadian Institute for Health Information: Canadian Agency for Drugs and Technologies in Health; 2017.

25. BCRenal. Hemodialysis Guideline Community Dialysis Units: Description, Selection Criteria, Services & Transitions ("Best Practices). http://www.bcrenalagency.ca/resource-gallery/Documents/Guideline Best Practices CDUs FINAL.pdf. Published 2018. Accessed July 14, 2019.

26. Diamant MJ, Harwood L, Movva S, et al. A comparison of quality of life and travel-related factors between in-center and satellite-based hemodialysis patients. *Clin J Am Soc Nephrol*. 2010;5(2):268-274. doi:10.2215/CJN.05190709

27. Organization WH. *International Classification of Functioning, Disability and Health: ICF*. Geneva: World Health Organization; 2001.

28. Koufaki P, Kouidi E. Current best evidence recommendations on measurement and interpretation of physical function in patients with chronic kidney disease. *Sport Med*. 2010;40(12):1055-1074. doi:10.2165/11536880-000000000-00000

29. Painter P, Marcus RL. Assessing physical function and physical activity in patients with CKD. *Clin J Am Soc Nephrol*. 2013;8(5):861-872. doi:10.2215/CJN.06590712

30. Painter P, Marcus R. Physical function and gait speed in patients with chronic kidney disease. *Nephrol Nurs J*. 2013;40(6):529-539. http://www.ncbi.nlm.nih.gov/pubmed/24579399.

31. Painter P. The importance of exercise training in rehabilitation of patients with

end-stage renal disease. *Am J kidney Dis Off J Natl Kidney Found*. 1994;24(1 Suppl 1):S2-9.

32. Konstantinidou E, Koukouvou G, Kouidi E, Deligiannis A, Tourkantonis A. Exercise training in patients with end-stage renal disease on hemodialysis: Comparison of three rehabilitation programs. *J Rehabil Med*. 2002;34(1):40-45. doi:10.1080/165019702317242695

33. Johansen KL, Chertow GM, Da Silva M, Carey S, Painter P. Determinants of physical performance in ambulatory patients on hemodialysis. *Kidney Int*. 2001;60(4):1586-1591. doi:10.1046/j.1523-1755.2001.00972.x

34. Kutner NG, Zhang R, Huang Y, Painter P. Gait Speed and Mortality, Hospitalization, and Functional Status Change among Hemodialysis Patients: A US Renal Data System Special Study. *Am J Kidney Dis*. 2015;66(2):297-304. doi:10.1053/j.ajkd.2015.01.024

35. Jassal SV, Karaboyas A, Comment LA, et al. Functional dependence and mortality in the international dialysis outcomes and practice patterns study (DOPPS). *Am J Kidney Dis*. 2016;67(2):283-292.

36. Dargent-Molina P, Favier F, Grandjean H, et al. Fall-related factors and risk of hip fracture: The EPIDOS prospective study. *Lancet*. 1996;348(9021):145-149. doi:10.1016/S0140-6736(96)01440-7

37. Tinetti ME, Speechley M, Ginter SF. Risk factors for falls among elderly persons living in the community. *N Engl J Med*. 1988;319(26):1701-1707.

38. Shin S, Chung HR, Fitschen PJ, et al. Postural control in hemodialysis patients. *Gait Posture*. 2014;39(2):723-727. doi:10.1016/j.gaitpost.2013.10.006

39. McAdams-DeMarco MA, Suresh S, Law A, et al. Frailty and falls among adult patients undergoing chronic hemodialysis: a prospective cohort study. *BMC Nephrol*. 2013;14(1):224.

40. Fried LP, Tangen CM, Walston J, et al. Frailty in Older Adults: Evidence for a Phenotype. *Journals Gerontol Ser A Biol Sci Med Sci*. 2001;56(3):M146-M157.

doi:10.1093/gerona/56.3.M146

41. Dalrymple LS, Kaysen GA, Chiang J, et al. Frailty Among Patients Receiving Hemodialysis: Evolution of Components and Associations With Mortality. *Journals Gerontol Ser A*. 2018;74(3):380-386. doi:10.1093/gerona/gly206

42. Johansen KL, Chertow GM, Jin C, Kutner NG. Significance of Frailty among Dialysis Patients. *J Am Soc Nephrol*. 2007;18(11):2960-2967. doi:10.1681/ASN.2007020221

43. Mcadams-Demarco MA, Walston JD, Segev DL, Segev D. Frailty as a Novel Predictor of Mortality and Hospitalization in Hemodialysis Patients of All Ages. *J Am Geriatr Soc*. 2013;61(21212134523456):896-901. doi:10.1111/jgs.12266

44. Pearson C, Janz T, Ali J. Mental and substance use disorders in Canada. 2013. https://www150.statcan.gc.ca/n1/en/pub/82-624-x/2013001/article/11855-eng.pdf?st=qaq1wQVP

45. Knoll AD, MacLennan RN. Prevalence and correlates of depression in Canada: Findings from the Canadian Community Health Survey. *Can Psychol*. 2017;58(2):116-123. doi:10.1037/cap0000103

46. Palmer S, Vecchio M, Craig JC, et al. Prevalence of depression in chronic kidney disease: Systematic review and meta-analysis of observational studies. *Kidney Int*. 2013;84(1):179-191. doi:10.1038/ki.2013.77

47. Farrokhi F, Abedi N, Beyene J, Kurdyak P, Jassal SV. Association between depression and mortality in patients receiving long-term dialysis: A systematic review and meta-analysis. *Am J Kidney Dis*. 2014;63(4):623-635. doi:10.1053/j.ajkd.2013.08.024

48. Lopes AA, Bragg J, Young E, et al. Depression as a predictor of mortality and hospitalization among hemodialysis patients in the United States and Europe. *Kidney Int*. 2002;62(1):199-207. doi:10.1046/j.1523-1755.2002.00411.x

49. Mapes DL, Lopes AA, Satayathum S, et al. Health-related quality of life as a predictor of mortality and hospitalization: The dialysis outcomes and practice

patterns study (DOPPS). *Kidney Int*. 2003;64(1):339-349. doi:10.1046/j.1523-1755.2003.00072.x

50. DeOreo PB. Hemodialysis patient-assessed functional health status predicts continued survival, hospitalization, and dialysis-attendance compliance. *Am J Kidney Dis*. 1997;30(2):204-212. doi:10.1016/S0272-6386(97)90053-6

51. Loos C, Briancon S, Frimat L, Hanesse B, Kessler M. Effect of End-Stage Renal Disease on the Quality of Life of Older Patients. *J Am Geriatr Soc*. 2003;51(2):229-233.

52. Frank A, Auslander GK, Weissgarten J. Quality of life of patients with end-stage renal disease at various stages of the illness. *Soc Work Health Care*. 2004;38(2):1-27.

53. Valderrabano F, Jofre R, Lopez-Gomez JM. Quality of life in end-stage renal disease patients. *Am J Kidney Dis*. 2001;38(3):443-464. doi:10.1053/ajkd.2001.26824

54. Kolewaski CD, Mullally MC, Parsons TL, Paterson ML, Toffelmire EB, King-VanVlack CE. Quality of life and exercise rehabilitation in end stage renal disease. *CANNT J*. 2005;15(4):22-29. http://www.ncbi.nlm.nih.gov/pubmed/16491995.

55. Zyoud SH, Daraghmeh DN, Mezyed DO, et al. Factors affecting quality of life in patients on haemodialysis: A cross-sectional study from Palestine. *BMC Nephrol*. 2016;17(1):1-12. doi:10.1186/s12882-016-0257-z

56. Musavian AS, Soleimani A, Masoudi Alavi N, Baseri A, Savari F. Comparing the effects of active and passive intradialytic pedaling exercises on dialysis efficacy, electrolytes, hemoglobin, hematocrit, blood pressure and health-related quality of life. *Nurs midwifery Stud*. 2015;4(1):e25922.

57. Daratha KB, Short RA, Corbett CF, et al. Risks of subsequent hospitalization and death in patients with kidney disease. *Clin J Am Soc Nephrol*. 2012;7(3):409-416.

58. Canadian Institute of Health Information. High Risk and High Cost Focus on Opportunities to Reduce Hospitalizations of Dialysis Patients in Canada. 2016.

https://secure.cihi.ca/free_products/report-corr-high-risk-high-cost-en-web.pdf.

59. Molnar AO, Moist L, Klarenbach S, et al. Hospitalizations in Dialysis Patients in Canada: A National Cohort Study. *Can J Kidney Heal Dis*. 2018;5:205435811878037. doi:10.1177/2054358118780372

60. Canadian Institute of Health Information. Canadian Organ Replacement Register Annual Report: Treatment of End-Stage Organ Failure in Canada, 2004 to 2013. 2015. https://secure.cihi.ca/free_products/2015_CORR_AnnualReport_ENweb.pdf

61. Naylor KL, Kim SJ, McArthur E, Garg AX, McCallum MK, Knoll GA. Mortality in Incident Maintenance Dialysis Patients Versus Incident Solid Organ Cancer Patients: A Population-Based Cohort. *Am J Kidney Dis*. 2019;73(6):765-776. doi:10.1053/j.ajkd.2018.12.011

62. Cheema B, Abas H, Smith B, et al. Progressive Exercise for Anabolism in Kidney Disease (PEAK): A Randomized, Controlled Trial of Resistance Training during Hemodialysis. *J Am Soc Nephrol*. 2007;18(5):1594-1601. doi:10.1681/ASN.2006121329

63. Chen JLTT, Godfrey S, Ng TT, et al. Effect of intra-dialytic, low-intensity strength training on functional capacity in adult haemodialysis patients: A randomized pilot trial. *Nephrol Dial Transplant*. 2010;25(6):1936-1943. doi:10.1093/ndt/gfp739

64. Miller BW, Cress CL, Johnson ME, Nichols DH, Schnitzler MA. Exercise during hemodialysis decreases the use of antihypertensive medications. *Am J Kidney Dis*. 2002;39(4):828-833. doi:10.1053/ajkd.2002.32004

65. Deligiannis A, Kouidi E, Tassoulas E, Gigis P, Tourkantonis A, Coats A. Cardiac effects of exercise rehabilitation in hemodialysis patients. *Int J Cardiol*. 1999;70(3):253-266. doi:10.1016/S0167-5273(99)00090-X

66. Parsons TL, King-VanVlack CE. Exercise and End-Stage Kidney Disease: Functional Exercise Capacity and Cardiovascular Outcomes. *Adv Chronic Kidney Dis*. 2009;16(6):459-481. doi:10.1053/j.ackd.2009.08.009

67. Mihaescu A, Avram C, Bob F, Gaita D, Schiller O, Schiller A. Benefits of exercise training during hemodialysis sessions: a prospective cohort study. *Nephron Clin Pract*. 2013;124(1-2):72-78.

68. Liu Y-MYM, Chung YCY-C, Chang JSJ-S, Yeh MLM-L. Effects of Aerobic Exercise During Hemodialysis on Physical Functional Performance and Depression. *Biol Res Nurs*. 2015;17(2):214-221. doi:10.1177/1099800414539548

69. Cho H, Sohng K-Y. The Effect of a Virtual Reality Exercise Program on Physical Fitness, Body Composition, and Fatigue in Hemodialysis Patients. *J Phys Ther Sci*. 2014;26(10):1661-1665. doi:10.1589/jpts.26.1661

70. Paglialonga F, Lopopolo A, Scarfia RV, et al. Intradialytic cycling in children and young adults on chronic hemodialysis. *Pediatr Nephrol*. 2014;29(3):431-438. doi:10.1007/s00467-013-2675-5

71. Marchesan M, Nunes VG da S, Rombaldi A. Physical training improves physical fitness and the quality of life of patients on hemodialysis. *Rev Bras Cineantropom Desempenho Hum*. 2014;16(3):324-344. doi:http://dx.doi.org/10.5007/1980-0037.2014v16n3p334

72. Painter P, Carlson L, Carey S, Paul SM, Myll J. Physical functioning and health-related quality-of-life changes with exercise training in hemodialysis patients. *Am J Kidney Dis*. 2000;35(3):482-492. doi:10.1016/S0272-6386(00)70202-2

73. Parsons TL, Toffelmire EB, King-VanVlack CE. The effect of an exercise program during hemodialysis on dialysis efficacy, blood pressure and quality of life in end-stage renal disease (ESRD) patients. *Clin Nephrol*. 2004;61(4):261-274.

74. Ouzouni S, Kouidi E, Sioulis A, et al. Effects of intradialytic exercise training on health-related quality of life indices in haemodialysis patients. *Clin Rehabil*. 2009;23(1):53-63. doi:10.1177/0269215508096760

75. Bastani M, Ghasemi G, Sadeghi M, Afshon A, Sadeghi H. The Effect of Selected Core Stability Exercises on Balance and Muscle Endurance in the Elderly Patients Undergoing Hemodialysis. *Phys Treat Specif Phys Ther J*. 2018;7(2):89-96. doi:10.32598/ptj.7.2.89

76. Parker K, Zhang X, Lewin A, MacRae JM. The association between intradialytic exercise and hospital usage among hemodialysis patients. *Appl Physiol Nutr Metab*. 2015;40(4):371-378. doi:10.1139/apnm-2014-0326

77. Painter P, Moore G, Carlson L, et al. Effects of exercise training plus normalization of hematocrit on exercise capacity and health-related quality of life. *Am J Kidney Dis*. 2008;39(2):257-265. doi:10.1053/ajkd.2002.30544

78. Sheng K, Zhang P, Chen L, Cheng J, Wu C, Chen J. Intradialytic exercise in hemodialysis patients: A systematic review and meta-analysis. *Am J Nephrol*. 2014;40(5):478-490. doi:10.1159/000368722

79. Jung T-D, Park S-H. Intradialytic Exercise Programs for Hemodialysis Patients. *Chonnam Med J*. 2011;47(2):61. doi:10.4068/cmj.2011.47.2.61

80. Molsted S, Eidemak I, Sorensen HT, Kristensen JH. Five months of physical exercise in hemodialysis patients: Effects on aerobic capacity, physical function and self-rated health. *Nephron - Clin Pract*. 2004;96(3):76-82. doi:10.1159/000076744

81. Manfredini F, Mallamaci F, D'Arrigo G, et al. Exercise in Patients on Dialysis: A Multicenter, Randomized Clinical Trial. *J Am Soc Nephrol*. 2017;28(4):1259-1268. doi:10.1681/ASN.2016030378

82. Tao X, Chow SKY, Wong FKY. A nurse-led case management program on home exercise training for hemodialysis patients: A randomized controlled trial. *Int J Nurs Stud*. 2015;52(6):1029-1041. doi:10.1016/j.ijnurstu.2015.03.013

83. Gomes Neto M, de Lacerda FFR, Lopes AA, Martinez BP, Saquetto MB. Intradialytic exercise training modalities on physical functioning and health-related quality of life in patients undergoing maintenance hemodialysis: systematic review and meta-analysis. *Clin Rehabil*. 2018;32(9):1189-1202. doi:10.1177/0269215518760380

84. Smart N, Steele M. Exercise training in haemodialysis patients: A systematic review and meta-analysis. *Nephrology*. 2011;16(7):626-632. doi:10.1111/j.1440-1797.2011.01471.x

85. Tentori F, Elder SJ, Thumma J, et al. Physical exercise among participants in the Dialysis Outcomes and Practice Patterns Study (DOPPS): Correlates and associated outcomes. *Nephrol Dial Transplant*. 2010;25(9):3050-3062. doi:10.1093/ndt/gfq138

86. Bennett PN, Breugelmans L, Barnard R, et al. Sustaining a hemodialysis exercise program: A review. *Semin Dial*. 2010;23(1):62-73. doi:10.1111/j.1525-139X.2009.00652.x

87. Painter P, Clark L, Olausson J. Physical function and physical activity assessment and promotion in the hemodialysis clinic: A qualitative study. *Am J Kidney Dis*. 2014;64(3):425-433. doi:10.1053/j.ajkd.2014.01.433

88. Parker K. Intradialytic Exercise is Medicine for Hemodialysis Patients. *Curr Sports Med Rep*. 2016;15(4):269-275. doi:10.1249/JSR.0000000000000280

89. Johansen KL, Kaysen GA, Young BS, Hung AM, da Silva M, Chertow GM. Longitudinal study of nutritional status, body composition, and physical function in hemodialysis patients. *Am J Clin Nutr*. 2003;77(4):842-846. doi:10.1093/ajcn/77.4.842

90. Johansen KL, Chertow GM, Ng A V., et al. Physical activity levels in patients on hemodialysis and healthy sedentary controls. *Kidney Int*. 2000;57(6):2564-2570. doi:10.1046/j.1523-1755.2000.00116.x

91. Delgado C, Johansen KL, Esfehani AJ, Dashti S. Barriers to exercise participation among dialysis patients. *Nephrol Dial Transplant*. 2012;27(3):1152-1157. doi:10.1093/ndt/gfr404

92. Kontos PC, Miller KL, Brooks D, et al. Factors influencing exercise participation by older adults requiring chronic hemodialysis: A qualitative study. *Int Urol Nephrol*. 2007;39(4):1303-1311. doi:10.1007/s11255-007-9265-z

93. Johansen KL. Physical Functioning and Exercise Capacity in Patient on Dialysis. *Adv Ren Replace Ther*. 1999;6(2):141-148.

94. Ma S, Lui J, Brooks D, Parsons TL. The availability of exercise rehabilitation

programs in hemodialysis centres in Ontario. *CANNT J*. 2012;22(4):26-32.

95. Young HML, Hudson N, Clarke AL, et al. Patient and staff perceptions of intradialytic exercise before and after implementation: A qualitative study. *PLoS One*. 2015;10(6):1-17. doi:10.1371/journal.pone.0128995

96. Bennett PN, Peter J, Wang W, Street M. Patient Exercise During Hemodialysis. *Nephrol Nurs J*. 2016;43(4):331-337.

97. Jhamb M, McNulty ML, Ingalsbe G, et al. Knowledge, barriers and facilitators of exercise in dialysis patients: a qualitative study of patients, staff and nephrologists. *BMC Nephrol*. 2016;17(1):1-14. doi:10.1186/s12882-016-0399-z

98. Aucella F, Battaglia Y, Bellizzi V, Bolignano D, Capitanini A, Cupisti A. Physical excercise programs in CKD: lights, shades and perspectives: a position paper of the “Physical Exercise in CKD Study Group” of the Italian Society of Nephrology. *J Nephrol*. 2015;28(2):143-150. doi:10.1007/s40620-014-0169-6

99. Kouidi E, Grekas D, Deligiannis A, Tourkantonis A. Outcomes of long-term exercise training in dialysis patients: comparison of two training programs. *Clin Nephrol*. 2004;61:S31-8.

100. Chan KE, Thadhani RI, Maddux FW. Adherence Barriers to Chronic Dialysis in the United States. *J Am Soc Nephrol*. 2014;25(11):2642-2648. doi:10.1681/ASN.2013111160

101. Nazly E Al, Ahmad M, Musil C, Nabolsi M. On Hemodialysis : A Qualitative Study. 2013;40(4):321-327.

102. Moran A, Scott PA, Darbyshire P. Existential boredom: The experience of living on haemodialysis therapy. *Med Humanit*. 2009;35(2):70-75. doi:10.1136/jmh.2009.001511

103. Bohm C, Stewart K, Onyskie-Marcus J, Esliger D, Kriellaars D, Rigatto C. Effects of intradialytic cycling compared with pedometry on physical function in chronic outpatient hemodialysis: a prospective randomized trial. *Nephrol Dial Transplant*. 2014;29(10):1947-1955. doi:10.1093/ndt/gfu248

104. T. H. Mercer, C. Crawford, N. P. Gleeson PFN. Improves Functional Capacity and Dialysis Patients. *Am J Phys Med Rehabil*. 2002;81(3):162-167.

105. Patsopoulos NA. A pragmatic view on pragmatic trials. *Dialogues Clin Neurosci*. 2011;13(2):217-224.

106. Greenwood SA, Naish P, Clark R, et al. Intra-Dialytic Exercise Training: a Pragmatic Approach. *J Ren Care*. 2014;40(3):219-226. doi:10.1111/jorc.12080

107. Matsufuji S, Shoji T, Yano Y, et al. Effect of Chair Stand Exercise on Activity of Daily Living: A Randomized Controlled Trial in Hemodialysis Patients. *J Ren Nutr*. 2015;25(1):17-24. doi:10.1053/j.jrn.2014.06.010

108. Matsumoto Y, Furuta A, Furuta S, et al. The impact of pre-dialytic endurance training on nutritional status and quality of life in stable hemodialysis patients (Sawada study). *Ren Fail*. 2007;29(5):587-593. doi:10.1080/08860220701392157

109. Song W-J, Sohng K-Y. Effects of Progressive Resistance Training on Body Composition, Physical Fitness and Quality of Life of Patients on Hemodialysis. *J Korean Acad Nurs*. 2012;42(7):947. doi:10.4040/jkan.2012.42.7.947

110. DePaul V, Moreland J, Eager T, Clase CM. The effectiveness of aerobic and muscle strength training in patients receiving hemodialysis and EPO: A randomized controlled trial. *Am J Kidney Dis*. 2002;40(6):1219-1229. doi:10.1053/ajkd.2002.36887

111. van Vilsteren MCB a., de Greef MHG, Huisman RM. The effects of a low-to-moderate intensity pre-conditioning exercise programme linked with exercise counselling for sedentary haemodialysis patients in The Netherlands: Results of a randomized clinical trial. *Nephrol Dial Transplant*. 2005;20(1):141-146. doi:10.1093/ndt/gfh560

112. Singh S, Kwon A, Whitehurst DGT, et al. Fall prevention mobile clinic: a novel fall prevention program for community-dwelling older adults. *Can J Aging/La Rev Can du Vieil*. 2018;37(4):482-495.

113. Ware JE, Sherbourne CD. The MOS 36-item short-form health survey (SF-36): I.

Conceptual framework and item selection. *Med Care*. 1992.

114. Herdman M, Gudex C, Lloyd A, et al. Development and preliminary testing of the new five-level version of EQ-5D (EQ-5D-5L). *Qual Life Res*. 2011;20(10):1727-1736. doi:10.1007/s11136-011-9903-x

115. Sheikh JI, Yesavage JA. Geriatric Depression Scale (GDS): recent evidence and development of a shorter version. *Clin Gerontol J Aging Ment Heal*. 1986.

116. Radloff LS. The CES-D scale: A self-report depression scale for research in the general population. *Appl Psychol Meas*. 1977;1(3):385-401.

117. Van Dam NT, Earleywine M. Validation of the Center for Epidemiologic Studies Depression Scale-Revised (CESD-R): Pragmatic depression assessment in the general population. *Psychiatry Res*. 2011;186(1):128-132. doi:10.1016/j.psychres.2010.08.018

118. Gardner MM, Buchner DM, Robertson MC, Campbel AJ. Practical implementation of an exercise-based falls prevention programme. *Age Ageing*. 2001;30(1):77-83. doi:10.1093/ageing/30.1.77

119. Borg Perception. The Borg CR Scales® Folder. *Borg Percept Hasselby, Sweden*. 2010.

120. Eric C. Otago Exercise Programme. To prevent falls in older adults. *Accid Compens Corp New Zeal*. 2008;(March):8-9. doi:10.1021/jp062864y

121. Johansen KL, Dalrymple LS, Delgado C, et al. Association between Body Composition and Frailty among Prevalent Hemodialysis Patients: A US Renal Data System Special Study. *J Am Soc Nephrol*. 2014;25(2):381-389. doi:10.1681/ASN.2013040431

122. Salter ML, Jaar BG, Walston JD, et al. Frailty as a Novel Predictor of Mortality and Hospitalization in Individuals of All Ages Undergoing Hemodialysis. *J Am Geriatr Soc*. 2013;61(6):896-901. doi:10.1111/jgs.12266

123. Washburn RA, Smith K, Jette A, Janney C. Physical Activity Scale for the Elderly: administration and scoring instruction manual. *Watert New Engl Res Inst*. 1991.

124. Guralnik JM, Simonsick EM, Ferrucci L, et al. A short physical performance battery assessing lower extremity function: Association with self-reported disability and prediction of mortality and nursing home admission. *Journals Gerontol*. 1994;49(2). doi:10.1093/geronj/49.2.M85

125. Kaysen GA, Larive B, Painter P, et al. Baseline physical performance, health, and functioning of participants in the Frequent Hemodialysis Network (FHN) trial. *Am J Kidney Dis*. 2011;57(1):101-112. doi:10.1053/j.ajkd.2010.08.021

126. Lattanzio F, Corsonello A, Abbatecola AM, et al. Relationship Between Renal Function and Physical Performance in Elderly Hospitalized Patients. *Rejuvenation Res*. 2012;15(6):545-552. doi:10.1089/rej.2012.1329

127. Reese PP, Cappola AR, Shults J, et al. Physical performance and frailty in chronic kidney disease. *Am J Nephrol*. 2013;38(4):307-315. doi:10.1159/000355568

128. Lopes AA, Albert JM, Young EW, et al. Screening for depression in hemodialysis patients: associations with diagnosis, treatment, and outcomes in the DOPPS. *Kidney Int*. 2004;66(5):2047-2053. doi:10.1111/j.1523-1755.2004.00977.x

129. Gerard K, Nicholson T, Mullee M, Mehta R, Roderick P. EQ-5D versus SF-6D in an older, chronically ill patient group. *Appl Health Econ Health Policy*. 2004;3(2):91-102. doi:10.2165/00148365-200403020-00005

130. Yang F, Lau T, Lee E, Vathsala A, Chia KS, Luo N. Comparison of the preference-based EQ-5D-5L and SF-6D in patients with end-stage renal disease (ESRD). *Eur J Heal Econ*. 2015;16(9):1019-1026. doi:10.1007/s10198-014-0664-7

131. Stevens PJ, Syddall HE, Patel HP, Martin HJ, Cooper C, Aihie Sayer A. Is grip strength a good marker of physical performance among community-dwelling older people? *J Nutr Heal Aging*. 2012;16(9):769-774. doi:10.1007/s12603-012-0388-2

132. Johansen KL, Painter P, Delgado C, Doyle J. Characterization of Physical Activity and Sitting Time Among Patients on Hemodialysis Using a New Physical Activity Instrument. *J Ren Nutr*. 2015;25(1):25-30. doi:10.1053/j.jrn.2014.06.012

133. van Reenen M, Janssen B. EQ-5D-5L User Guide: Basic Information on How to Use EQ-5D (v2.1). 2015;(April). http://www.euroqol.org/fileadmin/user_upload/Documenten/PDF/Folders_Flyers/EQ-5D-5L_UserGuide_2015.pdf.

134. EuroQol Research Foundation. EQ-5D-5L Available modes of administration. https://euroqol.org/eq-5d-instruments/eq-5d-5l-available-modes-of-administration/. Published 2019. Accessed July 14, 2019.

135. The Center for Innovative Public Health Research. About CESD-R. https://cesd-r.com/about-cesdr/. Accessed July 14, 2019.

136. Washburn RA, Smith KW, Jette AM, Janney CA. the Physical Activity (Pase): Development and Evaluation. *J Clin Epidemiol*. 1993;46(2):153-162. doi:10.1016/0895-4356(93)90053-4

137. Johansen KL, Painter P, Kent-Braun JA, et al. Validation of questionnaires to estimate physical activity and functioning in end-stage renal disease. *Kidney Int*. 2001;59(3):1121-1127. doi:10.1046/j.1523-1755.2001.0590031121.x

138. Washburn RA, McAuley E, Katula J, Mihalko SL, Boileau RA. The physical activity scale for the elderly (PASE): evidence for validity. *J Clin Epidemiol*. 1999;52(7):643-651.

139. Koufaki P, Greenwood SA, Macdougall IC, Mercer TH. Exercise Therapy in Individuals With Chronic Kidney Disease: A Systematic Review and Synthesis of the Research Evidence. *Annu Rev Nurs Res*. 2013;31(1):235-275. doi:10.1891/0739-6686.31.235

140. de Villar LOP, Martínez-Olmos FJ, Junqué-Jiménez A, et al. Test-retest reliability and minimal detectable change scores for the short physical performance battery, one-legged standing test and timed up and go test in patients undergoing hemodialysis. *PLoS One*. 2018;13(8):1-16. doi:10.1371/journal.pone.0201035

141. Tse ACY, Wong TWL, Lee PH. Effect of Low-intensity Exercise on Physical and Cognitive Health in Older Adults: a Systematic Review. *Sport Med - Open*. 2015;1(1). doi:10.1186/s40798-015-0034-8

142. Smith C. A, Burton O. J. Exercise in Kidney Disease and Diabetes: Time for Action. *J Ren Care*. 2012;38:52-58. doi:10.1111/j.1755-6686.2012.00279.x

143. K/DOQI Workgroup. K/DOQI clinical practice guidelines for cardiovascular disease in dialysis patients. *Am J Kidney Dis*. 2005;45(4 Suppl 3):S1-153. doi:10.1053/j.ajkd.2005.01.019

144. Delgado C, Johansen KL. Deficient counseling on physical activity among nephrologists. *Nephron - Clin Pract*. 2010;116(4). doi:10.1159/000319593

145. Johansen KL, Sakkas GK, Doyle J, Shubert T, Adams Dudley R. Exercise counseling practices among nephrologists caring for patients on dialysis. *Am J Kidney Dis*. 2003;41(1):171-178. doi:10.1053/ajkd.2003.50001

146. Bennett PN, Peter J, Wang W, Street M. Attitudes of nephrology nurses toward patient exercise during hemodialysis. *Nephrol Nurs J*. 2016;43(4):331-337.

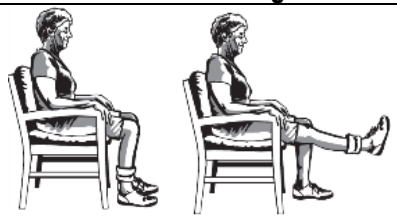
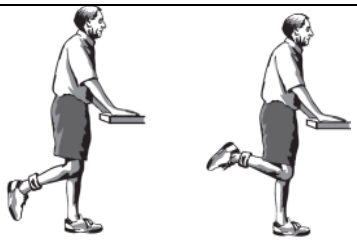
147. Painter P, Carlson L, Carey S, Myll J, Paul S. Determinants of exercise encouragement practices in hemodialysis staff. *Nephrol Nurs J*. 2004;31(1).

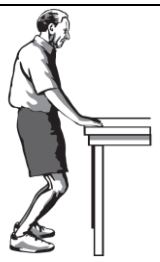
148. Bohm CJ, Storsley LJ, Hiebert BM, et al. Impact of Exercise Counseling on Physical Function in Chronic Kidney Disease: An Observational Study. *Can J Kidney Heal Dis*. 2018;5:205435811775361. doi:10.1177/2054358117753615

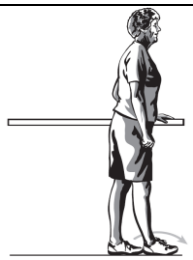
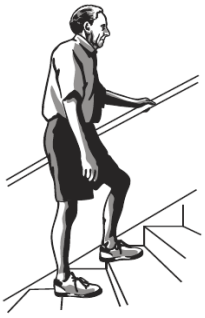
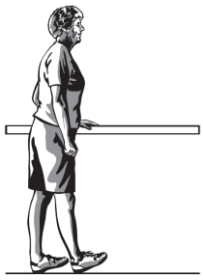
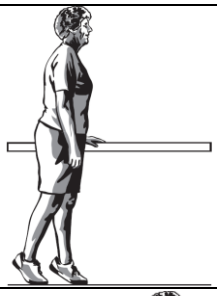
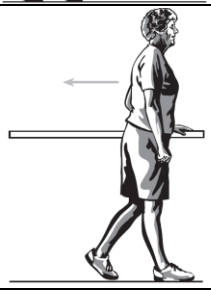
149. Jagannathan R, Ziolkowski SL, Weber MB, et al. Physical activity promotion for patients transitioning to dialysis using the “Exercise is Medicine” framework: a multi-center randomized pragmatic trial (EIM-CKD trial) protocol. *BMC Nephrol*. 2018;19(1):230.

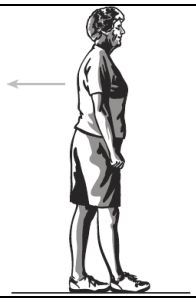
Appendix A.

The Adapted Otago Exercise Program for CDUs

Strengthening Exercises		
Exercise Name	**Description**	**Exercise Image**
Front Knee Strengthening Exercise	Seated exercise extending the leg to straight and lowering it (with an ankle weight, if appropriate)	
Back Knee Strengthening Exercise	A standing exercise bringing the foot towards the bottom (with an ankle weight, if appropriate)	
Side Hip Strengthening Exercise	A standing exercise lifting the leg out to the side (with an ankle weight, if appropriate)	
Calf Raises (holding support)	A standing exercise lifting the heels to come on to toes	
Toe Raises (holding support)	A standing exercise lifting the toes to come on to heels	

Fistula Exercises		
Exercise Name	**Description**	**Exercise Image**
Lower Arm Fistula Exercise	A hand squeezing exercise (with a hand exercise ball)	
Upper Arm Fistula Exercise	An arm exercise lifting the hand and bending at the elbow while holding a hand weight	
Initial Balance Exercises		
Exercise Name	**Description**	**Exercise Image**
Sit to Stand (two hand support, one hand support, or without hand support depending on level)	An exercise of slowly rising from the chair to a standing position and slowly returning to a sitting position in the chair	
One Leg Stand (holding support)	A standing exercise balancing on one leg at a time	
Knee Bends (holding support)	A standing exercise bending the knees to a mini squat	
Sideways Walking (holding support)	A standing exercise taking steps sideways	

Heel Toe Standing (holding support) **Progression:** Heel Toe Walking (holding support)	A standing exercise **standing** in tandem stance (feet heel to toe) **Progression:** A standing exercise **walking** in tandem steps (feet heel to toe)	
Modified Stair Walking (Marching on the Spot with Raising the Knees High)	A standing exercise marching on the spot and lifting knees high If stairs/steps are available, walk up and down the steps	
More Challenging Balance Exercises (Added to Progress Participants, As Appropriate)		
Exercise Name	**Description**	**Exercise Image**
Heel Walking (holding support)	A standing exercise walking on heels (with toes lifted)	
Toe Walking (holding support)	A standing exercise walking on toes (with heels lifted)	
Backwards Walking (holding support)	A standing exercise taking steps backwards	

Heel Toe Walking Backwards	A standing exercise **walking backwards** in tandem steps (feet heel to toe)	

Appendix B.

Exercise Program Attendance Form

Class Date:_____

Research ID	Time In	Time Out	How many minutes did you spend doing these exercises at home since the last session?	Any new/ unusual symptoms related to last exercise session?	How do you feel after today's exercise session? **1 (Very Poor) 2 (Poor) 3 (Fair) 4 (Good) 5 (Very Good)**	Did Not Attend: List Reason Examples: A – Absent L – Late S – Sick O – Other(Explain)	RPE (1-10)	Notes

Appendix C.

Research Participant Intake Form

1.) Sex: ☐ Male ☐ Female **2.)** Age:____ **3.)** Length of Time on Dialysis (Months): _____

4.) Height: _____ **5.)** Weight: _____ **6.)** BMI: _____

7.) What is your usual dialysis schedule (days and times):_____

8.) How do you get to your dialysis appointments:

☐ Family/Friend Drive ☐ Drive Self ☐ Transit ☐ HandyDart ☐ Taxi ☐ Walk

9.) Do you live:

☐ In your own house/apartment ☐ In a seniors residence/assisted living

☐ In residential care ☐ Other, please explain _____

10.) Do you use any mobility aids:

☐ Cane ☐ Walker ☐ Wheelchair ☐ None ☐ Other _____

Notes:_____

11.) How many times have you fallen in the **last 12 months**?

☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 or more

12.) Is English your first language?

☐ Yes ☐ No (If no, what is your first language? _____)

13.) What is your ethnic background?

☐ Caucasian ☐ Chinese ☐ Fijian ☐ South Asian

☐ Filipino ☐ African ☐ Arab ☐ Other _____

14.) Do you suffer from any of the following health problems?

Arthritis	☐ Yes	☐ No	☐ Unsure	
Osteoporosis	☐ Yes	☐ No	☐ Unsure	
Liver Disease	☐ Yes	☐ No	☐ Unsure	

High Blood Pressure	☐ Yes	☐ No	☐ Unsure	
Lung Disease	☐ Yes	☐ No	☐ Unsure	
	If yes, please list (eg. Asthma, COPD, Emphysema, Chronic Bronchitis, etc.):			
Heart Problems/ Cardiovascular Disease	☐ Yes	☐ No	☐ Unsure	
	If yes, please list (Coronary artery disease, Congestive heart failure, etc.):			
Stroke	☐ Yes	☐ No	☐ Unsure	
Peripheral Vascular Disease	☐ Yes	☐ No	☐ Unsure	
Diabetes	☐Type 1	☐Type 2	☐ No	
Parkinson's Disease	☐ Yes	☐ No	☐ Unsure	
Cancer	☐ Yes	☐ No	☐ Unsure	Location:

15.) List any past joint replacement surgeries (or amputations):

_____

16.) Have you lost 10 or more pounds unintentionally in the past year?

☐ Yes ☐ No ☐ Unsure _____

17.) What is your employment status:

☐ Employed ☐ Unemployed ☐ Retired

18.) What is your marital status:

☐ Single ☐ Married ☐ Widowed

☐ Other:(Common law, separated, divorced)_____

19.) Which of the following best describes your education level:

☐ Elementary school or less
☐ Some high school
☐ High school graduate
☐ Some college/university
☐ College diploma
☐ University degree
☐ Post graduate

Appendix D.

Instructor Feedback Survey

Please take a few minutes to fill out this confidential survey and express your opinions about the Dialysis Exercise Study. Your feedback is important and it will help us understand how we can improve this exercise program. For each question, please place a check mark (☑) in the most appropriate box.

How would you rate the following:	**Strongly Agree**	**Agree**	**Neutral**	**Disagree**	**Strongly Disagree**
1. Participants were generally motivated to participate in the exercise program.	☐	☐	☐	☐	☐
2. I would recommend holding this exercise program on this dialysis unit again.	☐	☐	☐	☐	☐
3. The sequence of the exercises was appropriate for the participants.	☐	☐	☐	☐	☐
4. This exercise program was well implemented.	☐	☐	☐	☐	☐
5. The exercises were well received by the participants.	☐	☐	☐	☐	☐
6. I would recommend holding the exercises before dialysis treatments.	☐	☐	☐	☐	☐
7. a) Participants experienced benefits from the exercise program.	☐	☐	☐	☐	☐
b) If applicable, please describe any benefits you felt that the participants experienced:					

7. How would you rate the intensity of the exercises for the participants?

☐ Too easy ☐ Easy ☐ Just right ☐ Hard ☐ Too hard

8. How would you rate the length of the exercise sessions?

☐ Too short ☐ Short ☐ Just right ☐ Long ☐ Too Long

9. Please provide any additional comments around the selection of the exercises.

10. Please provide any suggestions for improvements or comments for this exercise program.

11. Please provide a summary of your experiences with the exercise program and this research study. Please include any comments or feedback that would like to express about the exercise program and your experiences.

Appendix E.

CDU Staff Feedback Survey

Please take a few minutes to fill out this confidential survey and express your opinions about the Dialysis Exercise Study. Your feedback is important and will help us understand how we can improve this exercise program. For each question, please place a check mark (☑) in the most appropriate box.

How would you rate the following:	**Strongly Agree**	**Agree**	**Neutral**	**Disagree**	**Strongly Disagree**
1. This exercise program was well received by the patients.	☐	☐	☐	☐	☐
2. I would recommend hosting this exercise program on this dialysis unit again.	☐	☐	☐	☐	☐
3. This exercise program was well implemented.	☐	☐	☐	☐	☐
4. Patients were generally motivated to participate in the exercise program.	☐	☐	☐	☐	☐
5. I would recommend holding the exercises before dialysis treatments.	☐	☐	☐	☐	☐
6. a) Patients experienced benefits from the exercise program.	☐	☐	☐	☐	☐
b) If applicable, please describe any benefits that your patients experienced:					

7. Did this exercise program cause any disturbances to the unit?

☐ Yes ☐ Somewhat ☐ No

Please elaborate on the disturbances to this unit caused by the exercise program.

8. Please provide any suggestions for improvements or comments for this exercise program.

9. Please write any additional comments or feedback that would like to express about the exercise program and your experiences.

Appendix F.

Participant Feedback Survey

Please take a few minutes to fill out this confidential survey and express your opinions about the Dialysis Exercise Study. Your feedback will help us understand how we can improve this exercise program. For each question, please place a check mark (☑) in the most appropriate box.

1. How would you rate this exercise program?

☐ Excellent ☐ Very Good ☐ Good ☐ Fair ☐ Poor

2. How convenient was it to hold the exercise program before your dialysis treatments?

☐ Completely Convenient ☐ Very Convenient ☐ Somewhat Convenient ☐ Not very Convenient ☐ Not at all Convenient

3. How did you find the intensity of the exercises?

☐ Too easy ☐ Easy ☐ Just right ☐ Hard ☐ Too hard

4. How would you rate the length of the exercise sessions?

☐ Too short ☐ Short ☐ Just right ☐ Long ☐ Too Long

5. How likely are you to participate in this program again?

☐ Very Likely ☐ Likely ☐ Maybe ☐ Unlikely ☐ Very unlikely

6. Did you make any lifestyle changes as a result of participating in this exercise program (exercise at home, etc)?

☐ Yes → What are these changes: _____

☐ Somewhat

☐ No

7. Did participation in this program benefit you?

☐ Yes → What are the benefits you experienced: _____

☐ Somewhat

☐ No

8. Please provide any suggestions for improvements (what did you like, not like, etc.)

Appendix G.

Volunteer Feedback Survey

Please take a few minutes to fill out this confidential survey and express your opinions about the Dialysis Exercise Study. Your feedback is important and will help us understand how we can improve this exercise program. For each question, please place a check mark (☑) in the most appropriate box.

How would you rate the following:	**Strongly Agree**	**Agree**	**Neutral**	**Disagree**	**Strongly Disagree**
1. This exercise program was well received by the patients.	☐	☐	☐	☐	☐
2. I would recommend hosting this exercise program on this dialysis unit again.	☐	☐	☐	☐	☐
3. This exercise program was well implemented.	☐	☐	☐	☐	☐
4. Patients were generally motivated to participate in the exercise program.	☐	☐	☐	☐	☐
5. I would recommend holding the exercises before dialysis treatments.	☐	☐	☐	☐	☐
6. a) Patients experienced benefits from the exercise program.	☐	☐	☐	☐	☐
b) If applicable, please describe any benefits that your patients experienced:					

7. Did this exercise program cause any disturbances to the unit?

☐ Yes ☐ Somewhat ☐ No

Please elaborate on the disturbances to this unit caused by the exercise program.

8. Please provide any suggestions for improvements or comments for this exercise program.

9. Please provide a summary of your experiences with the exercise program and this research study. Please include any comments or feedback that would like to express about the exercise program and your experiences.