Chapter 1

INTRODUCTION

It has been estimated by the Organ Donor Foundation that at least ten people suffering from end stage renal disease (ESRD) in South Africa are sent home to die because of a shortage of space on dialysis machines (Molakeng, 2002). South African state hospitals only give dialysis to patients who are South African citizens, under 60 years or under 50 years if a diabetic, who are not HIV-positive or suffering from any other lifespan-limiting disease like cancer (Green, 2005).

The aforementioned problem has received huge media attention in South Africa in the last six years after a 51-year-old patient suffering with renal failure and diabetes was denied state treatment (Molakeng, 2002). The first patient who was turned away from a state hospital, approximately five years ago, took the matter to the Constitutional Court that ruled while the state had an obligation to treat someone in an emergency situation, it was under no obligation to treat chronic conditions if it did not have the funds to do so (Green, 2005). It has been estimated that 21 000 South African patients suffer with kidney failure and only 5 000 of these patients are treated while the remaining 15 000 patients cannot be treated because of a lack of organ donations, insufficient dialysis machines and exclusion arising from other significant diseases (Molakeng, 2002).

Research on the benefits of exercise during dialysis dates back 20 years when Painter et al (1986) first published a safe and beneficial method of exercising using a cycle ergometer. One study in the 80's (Carney et al, 1987) and two studies from the 90's (Moore et al, 1998 and Kong et al, 1999) confirmed these findings. Since then researchers have continued to conduct studies on this vulnerable population and have repeatedly established that exercise is safe, beneficial and improves the quality of life of patients with end stage renal disease, (Parsons et al, 2004; Oh-Park et al 2002 and Painter et al, 2000**a** and 2000**b**).

Research suggests that the efficacy of dialysis is improved with exercise by increased perfusion of skeletal muscles (Daul et al, 2004). Dialysis efficacy is expressed by Kt/V which is a dimensionless, mathematical representation of serum urea clearance that is calculated clinically by using pre and post-dialysis blood urea concentrations (O'Connor et al, 2002).

Kong et al (1999) conducted a study on 11 subjects who exercised on a cycle ergometer for a cumulative total of 60 minutes (3 x 20 minute sessions) in one dialysis session and reported a 15% increase in Kt/V. However, the study by Parsons et al (2004) did not produce similar improvements when their subjects exercised for 15 minutes per hour and they concluded that the intensity, modality and timing of exercise during dialysis should be altered to result in greater urea removal at the dialyzer to potentially enhance serum urea clearance. It is recommended that exercise during dialysis be done in a seated position to maintain a normotensive state during fluid removal with dialysis and to ensure that venous and arterial pressures are maintained constant in fistula lines (Parsons et al, 2004).

A general consensus among researchers on this topic is that exercise during dialysis should be done during the first 2 – 3 hours of a session and high ultra filtration rates should be avoided to prevent hypotensive episodes (Daul et al, 2004, Moore et al, 1998, Parsons et al, 2004).

Health related quality of life has been extensively researched in exercise and chronic disease and numerous studies done on patients with end stage renal disease have confirmed that exercise improves quality of life (Cheema et al, 2005; Painter et al, 2000**a** and 2000**b**; Parsons et al, 2004). Cleary and Drennan (2005) measured the overall quality of life of people receiving haemodialysis and compared their quality of life with that of the general population in Ireland. They concluded that patients receiving haemodialysis identified limitations in a number of areas including vitality, physical functioning and physical role limitations and reported significantly lower physical functioning when compared with the general populations' scores.

Despite these findings, exercise during dialysis is essentially non-existent in South Africa. This could be due to limited knowledge on the benefits of exercise among renal patients, a general lack of interest on the topic, or more likely, limited finances. Daul et al (2004) though state that "Even with respect to the financial aspects, few resources are needed to establish an exercise programme and reduce the total treatment costs of haemodialysis patients significantly by exercise rehabilitation".

A variety of validated questionnaires have been used to establish the quality of life of patients with end stage renal disease and according to Kouidi (2004), "it is difficult to distinguish which is the most appropriate." The EQ-5D health questionnaire is a reliable and validated instrument that has repeatedly been used to measure the quality of life of different populations and has been used successfully in other South African studies (Hughes et al, 2004; Jelsma et al, 2005) and for this reason has been selected to establish quality of life for this study.

Compression foot pumps are widely used to increase perfusion and reduce the risk of postoperative venous thrombosis (Fleming et al, 2000), but are generally used for post operative patients who are confined, for prolonged periods of time, to bed. Until very recently all compression foot pumps were electronic and considerably costly and not used for seated individuals.

The world's first manual compression foot pump was launched in South Africa in 2005 and based on market research is not only cost effective and portable, but incorporates aspects in its design that combine the benefits of electronic foot pumps and graduated compression stockings. (Endotec International – VASS technical manual, 2005)

The manual compression foot pump, commonly known as the "Venous Anti-Stasis Slipper (VASS) incorporates a simple yet effective mechanism that can significantly increase venous velocity in the lower limbs of seated individuals. Even though it was specifically designed to reduce lower limb swelling and the risk of deep venous thrombosis by improving venous velocity in seated individuals, its principles make it well suited for renal patients who sit for periods of four hours, three times a week.

This study aims to establish what effect the use of a manual compression foot pump will have on dialysis efficacy and the quality of life of patients with end stage renal disease. If so, a cost-effective and portable alternative could be used to replace bicycle ergometers commonly used in other renal units around the world and renal patients in South Africa could benefit from intradialytic exercise routines.

1.1 Research Question

Does the use of a manual compression foot pump improve dialysis efficacy and the quality of life of patients with end stage renal disease (ESRD)?

1.2 Aim of study

To establish what effect the use of a manual compression foot pump will have on dialysis efficacy and the quality of life of patients with ESRD.

1.3 Objectives of study

1.3.1 To compare pre and post exercise intervention, serum urea clearance levels (Kt/V values).

1.3.2 To compare pre and post exercise intervention, quality of life values (EQ-5D Health Questionnaire).

1.3.3 To establish the relationship between changes in Kt/V and the frequency of exercise.

Chapter 2

LITERATURE REVIEW

In this literature review the relevant literature concerning renal disease, the effects of exercise on dialysis efficacy and the quality of life of patients with ESRD will be reviewed. Evidence for the study design, selection criteria and outcome measures used in this study will be discussed.
The main search engine used for this review was Pubmed with a search of articles after 1980 (keywords – dialysis, exercise, intradialytic exercise, exercise renal disease, quality of life).

2.1 Background on Renal Disease

Renal failure (RF) is defined as that stage of renal function in which the kidney is no longer able to maintain the integrity of the internal environment of the organism (Llach, 1993). Loss of normal kidney function results in temporary or permanent damage to the kidneys. Temporary kidney damage results in acute renal failure that has a sudden onset and is potentially reversible. Permanent damage however progresses slowly and results in chronic renal failure (University of Virginia, Health System).

According to Wadhwa, chronic Renal Failure (CRF) progresses slowly and is defined as a permanent reduction in Glomerular Filtration Rate (GFR) sufficient to produce detectable alterations in well-being and organ function. This usually occurs at GFR below 25ml/min.

Decreased renal function is subdivided into four stages:

1. Silent – GFR up to 50ml/min.
2. Renal insufficiency – GFR 25 – 50 mil/min.
3. Renal failure – GFR 5 – 25mil/min.
4. End stage renal failure – GFR less than 5 ml/min (Wadhwa).

2.2 Causes of Chronic Renal Failure (CRF)

According to the nephrology channel, any disorder that permanently destroys nephrons in the kidneys can result in CRF. Chronic renal failure for this reason can also be classified according to the site of the damage, namely; pre-renal failure, post-renal failure and renal CRF.

The most common causes of CRF are however:

- Diabetic nephropathy
- Hypertensive nephrosclerosis
- Glomerulonephritis
- Interstitial nephritis &
- Polycystic kidney disease (Wadhwa).

The conditions above cause decreased renal function that results in an accumulation of nitrogenous waste products, chiefly urea, which are normally excreted into the urine thus causing toxicity in the blood.

2.3 Treatment of Renal Failure

Specific treatment for renal failure will differ from patient to patient depending on their age, overall health and medical history, as well as on the underlying cause and extent of their disease. It is important to treat the primary disease as it may cause continuous deterioration in renal function (University of Virginia, Health System).

Management may include:

- hospitalization.
- administration of intravenous fluids in large volumes.
- diuretic therapy or medication to increase urine output.

- regular monitoring of electrolyte levels such as potassium, sodium and calcium.
- medication to control blood pressure & associated illnesses e.g. diabetes specific diet requirements (University of Virginia, Health System).

When renal function deteriorates to a level where Glomerular Filtration Rate (GFR) falls below 5 m /min (ESRD), the patient usually cannot survive without renal replacement therapy. Renal replacement therapy includes dialysis and kidney transplantation, each with its associated complications and failure (Wadhwa).

According to the South African Nephrology Report of 2001, the prevalence of CRF in South Africa is unknown and accurate statistics for treatment rates are lacking by the South African Dialysis and Transplant Registry (SADTR) due to a lack of financial support since 1994. Treatment rates for 1994 showed that South Africa is grossly under-servicing its population, compared to other countries with a similar Gross Domestic Product (GDP).

2.4 Dialysis

Dialysis is a procedure that involves removing waste substances and fluid from the blood that are normally eliminated by the kidneys. There are two types of dialysis, namely peritoneal dialysis and haemodialysis.

Each type of dialysis has its advantages and disadvantages but is not a cure for ESRD. It enables patients with ESRD to live longer but needs to be done two to three times a week and sessions usually takes about four hours. Making a connection with the patients' circulation is very important and is usually done by an arteriovenous (AV) fistula which is formed by the joining of an artery and a vein, usually in the patients' arm (University of Virginia, Health System). The choice of site is dictated by availability of vessels, plans for future AV fistulas and left-right neurological dominance are also considered. Most shunts are made for immediate but temporary use and are therefore placed in the dominant arm, preserving the other for a fistula later (Morgan, 1973).

During haemodialysis, the patient's blood is passed through a filter outside the body and then reintroduced to the patient. Tiny pores in the filter membrane filter out toxins while vital components such as proteins are left in the blood. Excess water can also be removed through these filters and the entire process is controlled by the dialysis machine which is equipped with a blood pump and a monitoring system to ensure safety (Fresenius Medical Care, 2004).

Many patients with ESRD receive dialysis for many years in the hope of undergoing kidney transplantation**.** Some people in South Africa have waited a lifetime for donations and many others have died in the meantime (Molakeng, 2002).

The sedentary nature of many of these patients confined to a chair for approximately four hours a day, three times a week in conjunction with the symptoms mentioned earlier, results in further physical and psychological complications. Prolonged inactivity reduces the physiologic reserve of most organ systems, particularly the musculoskeletal and cardiopulmonary systems resulting in reduced circulation, muscle atrophy and joint stiffness, which ultimately reduce mobility, functional abilities and eventually quality of life (Rousseau, 1993).

According to Green (2005), an excuse for not implementing intradialytic exercise routines is limited finances. State hospitals in South Africa are stretching their financial resources and staff beyond their limits and some like the Chris Hani-Baragwanath Hospital is reportedly treating 160 patients when they only have space to accommodate 140 patients. The estimated cost to the state for each patient receiving dialysis is R15 000 per month (Green, 2005).

Dual et al (2004) highlighted that physical training helps elderly patients to maintain their autonomy, and in some cases, it even helps them to regain their personal independence.

Five of their patients, who had to be previously driven to their dialysis sessions by stretcher transportation, improved so much physically that they could use a taxi again. This had a positive effect on the psychosocial situation of the patients and also helped to decrease treatment costs. Their research has shown that "even with respect to the financial aspects, few resources are needed to establish an exercise programme and the total treatment costs of haemodialysis patients can be significantly reduced by exercise rehabilitation" (Daul et al, 2004).

2.5 End Stage Renal Disease (ESRD)

ESRD is the point in kidney failure when approximately 90% of renal function has been lost, rendering the body incapable of maintaining proper fluid and electrolyte balance, adequate waste removal, and normal hormonal function (Zawada, 2001). To ensure survival, patients with ESRD have to undergo renal replacement therapy, which includes a kidney transplant, peritoneal dialysis or haemodialysis.

Despite regular haemodialysis to replace some of the lost kidney function, patients on haemodialysis suffer a wide variety of ailments due to "uraemic" syndrome. Biopsy studies in haemodialysis (HD) patients revealed that skeletal muscles commonly have abnormal structure and function (Diesel et al, 1993). Common problems include a 50% reduction in physical work capacity to age and sex matched subjects, decreased health related quality of life and various cardiovascular diseases including left ventricular hypertrophy, congestive cardiac failure, coronary artery disease and hypertension (Diaz-Buxo et al, 2000; Horl & Horl, 2002).

Patients with ESRD suffer from exercise intolerance and experience progressively worsening disability and quality of life (Kouidi et al, 1997). They have high rates of self-reported physical disability, being almost unable to perform activities of everyday life (Diaz-Buxo et al, 2000). Hypertension is common among haemodialysis patients with approximately 50% to 90% of this population having a blood pressure greater than 140/90 mmHg. Numerous factors account for the hypertension with ESRD which include expanded extra cellular fluid volume, increased sympathetic nervous system activity, impaired vasodilatation, corrected renal anaemia, hyperparathyroidism, sodium balance and dialysis regimen (Horl & Horl, 2002).

Hsieh et al (2006) investigated maximal cardiovascular fitness in ambulatory haemodialysis patients and correlates of maximal oxygen consumption with functional and physical performance, psychiatric symptoms, cognitive function, quality of life, and duration of dialysis therapy and adequacy of dialysis were also examined. They found that ambulatory haemodialysis patients had 72% to 79% of physical performance and 71% of maximal oxygen consumption compared with age-matched controls. They concluded that additional fitness training programmes are needed for ambulatory haemodialysis patients.

2.6 Exercise and ESRD

Research on the benefits of exercise during dialysis dates back 20 years when Painter et al (1986) first published a safe and beneficial method of exercising using a cycle ergometer. Fourteen haemodialysis patients participated in a six month exercise programme, with six of the patients as controls not performing exercise. Their patients cycled behind the ergometer from their dialysis chair initially, but could progress to pedaling on the ergometer chair if they so wished. Their programme started with five minutes of continuous exercise and gradually progressed according to individual tolerance (between two and five minutes a session) to at least 30 continuous minutes during every treatment. The exercise group showed a significant increase of 23% in maximal oxygen consumption over the six months and no changes in exercise capacity resulted in the control group. Five of eight hypertensive patients in the exercise group decreased or discontinued antihypertensive medications but no changes occurred in haematocrit or lipid profiles in either group. The results of this study concluded that exercise during dialysis is technically feasible and safe for appropriately screened individuals and can increase exercise capacity and may be an effective therapy for decreasing cardiovascular disease in end-stage renal disease. Miller et al (2002) confirmed the lowering effect of cycling during dialysis. Out of the 24 hypertensive patients who participated in ergometric training for six months, 54% could reduce antihypertensive medication while a comparable reduction was only possible in 12.5% of sedentary controls (Miller et al, 2002).

These findings supported the findings of Goldberg et al (1986) and by Carney et al (1987) who too showed that regular training enhances physical ability in all stages of chronic renal failure and lessens the severity of accompanying diseases that renal patients often experience. Despite these positive findings, this type of exercise programme was not implemented on a large scale in the following years. A possible reason for this was identified by Johansen et al (2003) when they reported that although 97% of 505 nephrologists surveyed agreed that physical activity is important for their patients, only 38% regularly asked and counselled their patients on physical activity participation, and only 5% stated that they regularly provided written materials on physical activity to their patients.

Since these first studies, researchers have continued to conduct studies on this vulnerable population and they have repeatedly established that exercise is safe and beneficial and improves the quality of life of patients with end stage renal disease (Parsons et al, 2004; Oh-Park et al 2002; Painter et al, 2000**a**). Painter et al, (2000**b**) compared physical functioning and self-reported quality of life between two different functional groups of patients. They concluded that low functioning haemodialysis patients can benefit from exercise in both objective measures of physical functioning and self-reported physical functioning. Oh-Park et al (2002), conducted a study on 22 haemodialysis patients to investigate the safety and feasibility of aerobic and strength training during haemodialysis to evaluate its impact on their cardiac fitness, muscle strength and functional status. They concluded that a well designed exercise programme during haemodialysis can be performed safely with proper supervision and patient education, improving muscle strength, mental and physical function, and possibly cardiac fitness. Parsons et al (2004) investigated the effects of an eight-week exercise programme, using a cycle ergometer at 40 - 50% maximal work capacity for 15 minutes during each of the first three hours of dialysis, on dialysis efficacy, blood pressure and quality of life of patients with ESRD. They concluded that exercise during dialysis enhanced dialysate urea removal but not serum urea clearance and that the exercise programme had no effect on QOL scores due to the short duration of the study and the high functional level of the population studied.

To measure patients' maximum oxygen capacity a maximum exercise test on a treadmill or bicycle ergometer is needed. These tests are generally elaborate and costly and cannot be performed in every renal unit or dialysis centre. To overcome this problem, Daul et al (2004) used the Borg-Scale (Borg, 1982) for the subjective perception of exertion to control exercise intensity. They concluded that exercise training during dialysis is the first kind of renal exercise rehabilitation which is accepted by a relevant number of patients and which is carried out over months and even years.

Intradialytic exercise has positive effects on the physical and psychological situations of the patients which are similar to those of outpatient group exercises (Daul et al, 2004). Konstantinidou et al (2002) conducted a study in which they compared three rehabilitation programmes. All the exercise programmes were six month in duration and included one group (n = 16) that completed three weekly sessions of aerobic and strength training on non-dialysis days, another group (n = 10) that completed an exercise programme during dialysis and a third group (n = 10) that followed an unsupervised moderate exercise programme at home. These three groups were compared to a control group of sedentary individuals (n = 15) that were matched for gender and age. The results of this study demonstrated that intense exercise training on non dialysis days is the most effective way of training, whereas exercise during haemodialysis is also effective and preferable.

These findings confirmed results from other studies where researchers have found that intradialytic exercise (exercise during dialysis) gives similar benefits to exercise off dialysis and is more convenient, improves adherence to training and allows for less time commitment for subjects and medical supervision (Painter, 1994, Moore et al, 1998, Parsons et al, 2004.)

It is recommended that exercise during dialysis be done in a seated position to maintain a normotensive state during fluid removal with dialysis and to ensure that venous and arterial pressures are maintained constant in fistula lines (Parsons et al, 2004). Moore et al (1998) suggested that an ultra-filtration rate higher than 1000 ml/hour or a total fluid removal above 2500 ml could cause muscle cramps and cardiovascular problems which prevent physical exercise training. A general consensus among researchers is that exercise during dialysis should only be done during the first two to three hours of a dialysis session and high ultra filtration rates should be avoided to prevent hypotensive episodes (Daul et al, 2004; Moore et al, 1998; Parsons et al, 2004). Muscle cramps, usually of the lower extremities, are a common complaint during haemodialysis. The onset is usually near the end of the dialysis session, at a point where net fluid removal is greatest. The incidence has been found to correlate with the ultra filtration rate and the net amount of fluid removed (Neal et al, 1981).

The most recent study however, by Parsons et al (2006), advises that exercise sessions should be of longer duration and should only be done in the first two hours of dialysis. They found that two 30-minute exercise bouts with a 30-minute recovery period between bouts during the first two hours of a four hour dialysis session are far more effective than the three 15-minute bouts of exercise that they used in their 2004 study.

To date, there have been at least 42 publications of the effects of exercise training in patients with ESRD. The overall findings of these studies indicate that exercise training in ESRD results in improvements in cardiorespiratory function, aerobic training, cardiac functioning, skeletal muscle architecture and neuromuscular function, as well as clinical issues such as hypertension, insulin sensitivity and lipid profile (Painter and Johansen, 2006).

An interesting observation on reviewing the literature is that a large number of studies only include subjects attending three dialysis sessions per week, yet a large proportion of renal patients only attend two renal sessions per week. Apart from the study by Moug (2004) that involved two exercise sessions per week, no other reference is made to the frequency of exercise per week and its overall effect on dialysis efficacy, which might be an important factor that warrants further investigation.

2.7 Dialysis efficacy

Kt/v expresses dialysis efficacy, which is a dimensionless, mathematical representation of serum urea clearance that is calculated clinically by using pre and post-dialysis blood urea concentrations (O'Connor et al, 2002).

The fractional clearance is quantitatively defined as Kt/V where:

K = dialyser urea clearance (ml/min)	: 90% of blood flow rate in high flux dialysers
t = total treatment time (minutes)	: Hours on dialysis X 60 minutes
V = urea distribution volume (ml)	: Weight in Kg. X 58% x 1000

(Fresenius Medical Care, 2004).

The majority of published studies of dialysis efficacy have used the single-pool Kt/V (spKt/V) ratio as a measure of urea removal. The spKt/V ratio was popularized by Gotch and Sargent (1985) in their reanalysis of the National Cooperative Dialysis Study. In their study, a spKt/V value less than 0.8 was found to be associated with a high likelihood of morbidity and /or treatment failure. Since that time, a number of additional studies have been published or presented suggesting that the delivered spKt/V is related to mortality in dialysis patients (Daugirdas et al, 2001)

The general hypothesis about exercise during dialysis is that it results in increased blood flow to exercising muscles which results in the movement of toxins from the tissue to the vascular compartments for subsequent removal at the dialyser (Parsons et al, 2006.)

Only four studies have reported data related to dialysis efficacy with exercise during dialysis. Kong et al (1999) reported a 15% increase in Kt/V after their subjects (n = 11) exercised on a cycle ergometer for a cumulative total of 60 minutes in one dialysis session. Cappy et al (1999) had three exercise groups that cycled before or during dialysis, or performed work on a treadmill before dialysis for 20 - 40 minutes each session for periods of three, six or twelve months. They however reported Kt/V to increase 3%, decrease 9% and increase 11% at three, six and twelve months respectively resulting in no significant change in overall Kt/V. Unfortunately these two studies did not report the intensity of the exercise sessions and specifications regarding those subjects who exercised during dialysis and those who did not, were not reported. Parsons et al (2004) however, conducted an eight week exercise programme during dialysis in which their patients (exercise group, n = 6) performed cycle ergometry exercise three times per week at 40% - 50% maximal work capacity for 15 minutes during each of the first three hours of dialysis and were matched for age, protein catabolism rate and maximal work capacity with a control group (control, n = 7). They found no significant increase in Kt/v and concluded that the intensity, modality and timing of exercise during dialysis should be altered to result in greater urea removal at the dialyzer to potentially enhance serum urea clearance. The most recent study by Parsons et al (2006) measuring dialysis efficacy (spKt/V), physical function (6-minute walk test) and quality of life (KDQOL), found that a five month intradialytic exercise programme, in which subjects exercised three times a week (cycle ergometer, mini-stepper) for 30 minutes in each of the first two hours of haemodialysis, produced an 11% increase in SpKt/V at the end of the first month of the programme and remained elevated for the duration of the programme (18% - 19%). The distance walked on the 6-minute walk test (6MWT) increased by 14% at both weeks 10 and 20 ($P < 0.05$) with no changes noted in QOL using the Kidney Disease Quality of Life-Short Form (KDQOL).

2.8 Quality of Life

There has been a shift in the focus of research over the years and it is apparent from reviewing the literature on this topic, that researchers of renal diseases agree that it is important to measure not only the quantity of life, but also the quality of life of patients (Cleary and Drennan, 2005).

Health-related quality of life (HRQoL) consists of a number of components like functional status, psychological and social functioning, cognition and disease and treatment-related symptoms (Koudi, 2004). Advances in the management of patients with ESRD over the last decades seem to have had a positive effect on their functional status and health related QOL (Paganini, 1994; Hruska and Teitelbaum, 1995).

ESRD is a progressive, debilitating, chronic illness requiring nursing and medical interventions. The development of the disease affects QOL, potentially influencing physical and mental health, functional status, independence, general well-being, personal relationships and social functioning (Bakewell et al, 2002; Suet-Ching, 2001; Lok, 1996).

Moug et al (2004) conducted a six week study, using a cycle ergometer twice weekly, for a total of 12 sessions during dialysis. Their exercise group (n=10) showed a statistically significant increase in work rates during the 12 sessions and a reduction in anxiety. They confirmed that aerobic exercise during dialysis is not only feasible and well accepted by patients on hospital haemodialysis, but that it reduced their anxiety scores and showed a trend for an improved level of aerobic fitness.

It is believed by Parsons et al (2004) that intradialytic exercise programmes produce greater internal changes to influence the efficacy of dialysis than those programmes performed between dialysis sessions. This is because during exercise, metabolic requirements of the working muscles are met by both increased blood flow and increased oxygen extraction which is accomplished by opening of the capillary beds to reduce diffusion distance and increasing vascular cross-sectional surface area for exchange of substances between the tissue and vascular compartment. These haemodynamic alterations in working muscles in patients undergoing haemodialysis enhance the movement of various substances such as urea and potassium, from the tissue into the vascular compartment for removal at the dialyzer. In doing so, the greater removal of such toxins may result in improved muscle performance and increased exercise capacity and improvements in other functional outcomes such as quality of life in patients with ESRD.

The study by Cleary and Drennan (2005) measured the overall quality of life of people receiving haemodialysis and compared their quality of life with that of the general population in Ireland. A descriptive, cross-sectional health-status survey of the quality of life of patients undergoing haemodialysis treatment was carried out using the 36-item Short Form Health Survey questionnaire (SF-36). A total of 97 patients took part in their study and were divided into two sub-groups according to dialysis adequacy, measured by Kt/V levels. Those with a Kt/V greater than or equal to 1.2 (adequate dialysis) formed one group (n = 44), and those with Kt/V less than 1.2 (less than adequate dialysis) comprised the other group. They concluded that patients receiving haemodialysis identified limitations in a number of areas including vitality, physical functioning and physical role limitations and reported significantly lower physical functioning when compared with the general population's scores. Differences were also found in mental health scores between patients who were adequately dialysed and those inadequately dialysed.

A variety of validated questionnaires have been used to establish the quality of life of patients with end stage renal disease and according to Kouidi (2004), "it is difficult to distinguish which is the most appropriate."

Among the published studies of HRQoL in ESRD patients, a variety of generic and disease-specific questionnaires have been used (Kouidi, 2004; Rabin and de Charro, 2001). Some of the commonly used generic instruments in the ESRD population are:

- The Cambell Indices
- The Nottingham Health Profile
- The Time Trade-Off (TTO)
- The Karnofsky Performance Scale (KPS)
- The Sickness Impact Profile (SIP) &
- The Short Form-36 Health Survey questionnaire (SF-36)
- The Kidney Disease Quality of Life-Short Form (KDQOL) (Kouidi, 2004) and
- The EQ-5D (Rabin and de Charro, 2001).

The EQ-5D is a reliable and validated generic measure of health status developed by an international research group, the EuroQol Group. Initially developed simultaneously in Dutch, English, Finnish, Norwegian and Swedish, the EQ-5D is now available in most major languages and cultural adaptations, including South African English and Afrikaans (Rabin and de Charro, 2001). The principal aims of the EuroQol group are the development of a standardized, non-disease-specific instrument for describing and valuing health-related quality of life that would complement, rather than replace, other health-related quality of life measures. The EQ-5D is increasingly being used in a variety of ways including: monitoring the health status of patient groups at different times; assessing the seriousness of conditions at different times; providing evidence about medical effectiveness of drugs or processes to obtain approval in economic studies; establishing levels of population health status both locally and nationally (Rabin and de Charro, 2001). To date there are approximately 500 registered studies in the EQ-5D data base with more than 10 studies on renal diseases and by 2001, eight out of the first 10 of the top 50 pharmaceutical companies listed in the annual report of Pharma Business are using the EQ-5D and there are nearly 300 EQ-5D references in peer review journals (Rabin and de Charro, 2001).

2.9 Foot pumps

A study by Dinenno et al (1999) confirmed that whole limb blood flow at rest declines with advancing age in healthy adult humans. This appears to be due to a lower limb vascular conductance associated with an elevated sympathetic vasoconstrictor state and a reduction in oxygen demand per unit tissue mass. Compression foot pumps are widely used to increase perfusion and reduce the risk of postoperative venous thrombosis (Fleming et al, 2000), but are generally used for post operative patients who are confined to bed for prolonged periods of time. All intermittent compression systems have a simple main objective, and that is to squeeze blood from the underlying deep veins, which assuming that the valves are competent, will be displaced proximally. On deflation of the cuff, the veins will refill, and due to the intermittent nature of the system will ensure periodic flow of blood through the deep veins, so long as there is a blood supply (Morris and Woodcock, 2004).

Until very recently all compression foot pumps were electronic and very costly and only used for individuals confined to bed, usually after surgery. The world's first manual compression foot pump was launched in South Africa in 2005 and according to market research, is not only cost effective and portable, but incorporates aspects in its design that combine the benefits of electronic foot pumps and graduated compression stockings (Endotec International – VASS technical manual 2005).

Franks and Posnett (2003) in the Position Document of the European Wound Management Association (EWMA) on the topic of cost-effectiveness of compression stated that "cost-effectiveness is about ensuring that available resources are used in the most efficient way to improve the health-related quality of life of patients as a whole. When budgets are constrained, it may be more effective to treat 30 patients with a less effective therapy than treat 25 with the best".

The manual compression foot pump, commonly known as the "Venous Anti-Stasis Slipper" (VASS), incorporates a simple, yet effective mechanism that can significantly increase venous velocity in the lower limbs of seated individuals (Endotec International – VASS technical manual 2005.) Even though it was specifically designed to reduce lower limb swelling and the risk of deep venous thrombosis by improving venous velocity in seated individuals, its principles make it well suited for renal patients who sit for periods of four hours, two to three times a week.

There appear to be no published studies on the effects of compression foot pumps on dialysis efficacy and quality of life of patients with ESRD.

2.10 Summary

Exercise appears to stand out as an intradialytic intervention that not only results in an improvement in dialysis efficacy and a number of physical and functional improvements, but more importantly has the potential to improve the quality of life of patients with ESRD. Despite these findings, exercise during dialysis is essentially non-existent in South Africa, and it is more than likely due to limited finances and not a lack of knowledge on the subject. The introduction of the world's first manual compression foot-pump, the "venous anti-stasis slipper" immediately made an alternative instrument available to the commonly used cycle ergometers, that not only facilitates exercise, but has the ability to enhance lower limb circulation to improve the efficacy of dialysis.

Chapter 3

METHODOLOGY

In this chapter the study design, selection of subjects, criteria for inclusion and exclusion, measurements, procedure and statistical analysis will be discussed.

3.1 Study Design

A single group time series design was used to collect data for this study. The study consisted of an eight week non intervention period followed by an eight week intervention period.

3.2 Ethical clearance

The study was passed by the committee for research on human subjects of the University of the Witwatersrand (protocol number M060343) (Appendix 1).
Informed consent was obtained from all the subjects in the study (Appendix 3).
Informed consent to conduct the study was obtained from the hospital manager, the renal unit manager and the attending physician / nephrologist at Flora Clinic (Appendix 4).

3.3 Sample selection

The whole population of 34 self-care haemodialysis outpatients who attend two or three dialysis sessions per week at the Flora Clinic Renal Unit was initially considered for inclusion in the study. They were screened and cleared by their attending physician / nephrologists and all suitable subjects were invited to participate in the study. All subjects who had the following impairments were excluded from the study:

- Patients with lower limb amputations
- Severe paralytic conditions and physical disabilities

- Cognitive impairments
- Unstable hypertension
- Congestive heart failure
- Cardiac arrhythmias
- Recent myocardial infarction
- Unstable angina
- Any patient doing regular physical exercise.

3.3.1 Sample size

Nineteen subjects were finally selected from the total of 34 self-care haemodialysis patients and they were invited to participate in the study. Due to the fact that subjects were divided into four separate groups for dialysis, the sample population was divided into four groups to accommodate each subject's usual routine.

3.4 Procedure

The nineteen patients were invited to participate in this study. An information sheet (appendix 2) was given to them and consent forms (appendix 3) were signed. After informed consent had been obtained, baseline quality of life values were established with the use of the South African English version of the EQ-5D health questionnaire (Appendix 6) and baseline dialysis efficacy values (Kt/V) were obtained from analysis of blood results prior to the study. Permission to use the EQ-5D health questionnaire was obtained from the EuroQol Group (Appendix 5a and 5b). This was followed by an eight week non-intervention period, during which time patients followed their usual management routines.

On the first day of the intervention period of the study, pre-intervention quality of life and dialysis efficacy values were then established with the EQ-5D health questionnaire and by analysis of routine blood test results.

Each subject was issued with a pair of “venous anti-stasis slippers” (manual compression foot-pumps) that they would wear on their feet while they performed seated calf raising exercises during their dialysis sessions. These slippers were pre-inflated to 50mmHg at the start of each dialysis session and were inspected twice per week for the duration of the study to ensure that there were no leaks that could result in pressure changes.

Each subject was issued with a digital stopwatch at the beginning of each session to record the total time they exercised with the “slippers” during each dialysis session and times were recorded on a time sheet for each exercise session.

Subjects were connected to the dialysis machines as per their usual routines by the renal nurses and were asked to remain seated in an upright position with their feet flat on the floor for the period they were exercising.

The pre-inflated “slippers” were applied to the subjects’ feet by the investigator and subjects were instructed to begin exercising rhythmically by alternatively raising their heels, (seated calf raises) and to ensure that they exerted adequate pressure with downward movements to move air from one “slipper” to the other. Exercise sessions were supervised by the investigator and nursing sisters who were trained to use the “slippers” during a pilot study conducted in the vascular unit at Flora Clinic.

The Borg scale for perceived exertion (Borg, 1982) was used by each subject to regulate and record the intensity of each exercise session (Appendix 7). These values along with heart rates that were established by taking the patient’s pulse rates at their wrists at the start and end of each exercise session were recorded on each subject’s exercise diary along with the exercise duration for each session (Appendix 8). Each subject’s blood pressure was monitored routinely every hour by the renal nurses.

Subjects were asked to attempt to exercise for at least 20 minutes per hour for each of the first three hours of their dialysis sessions and to record the total time exercised per session on a time sheet. Subjects who felt comfortable to exercise more than 20 minutes per hour were allowed to do so as the exercise mostly involved the calf muscles and was not as strenuous as that of other studies where cycle ergometers were used to include the muscles of the hips and thighs.

The subjects were allowed to rest at the end of each 20 minute exercise session per hour and could remove their “slippers” and elevate their legs if they wished to do so.

Trained nursing staff with resuscitation equipment was in the renal unit at all times to ensure the safety of the patients and an emergency bell linked to the medical intensive care unit was available in case of an emergency.

At the end of the third hour of each session, each subject’s “slippers” were collected and placed in a labeled bag and stored in the renal unit for safekeeping.

Stopwatches were collected and total exercise times and exercise intensity scores were recorded in exercise dairies by the investigator.

This procedure was repeated two to three times per week for eight weeks, depending on the number of dialysis sessions the subjects attended, and routine blood test results were analyzed at the end of weeks 4 and 8 to obtain serum urea clearance levels (Kt/V).

The subjects completed the EQ-5D health questionnaires at the end of the eight week programme to establish post intervention quality of life values.

3.5 Statistical Analysis

Descriptive statistics were used to summarize the data obtained from the EQ-5D health questionnaires. The level of a reported problem on each of the EQ-5D dimensions determines a unique health state (One of 243). Data were converted to numeric totals with the aid of value sets obtained from the EuroQol group. These totals lie on a scale on which full health has a value of 1 and dead has a value of 0. A MANOVA was used to compare changes in scores between the subjects at baseline (week 0), pre-intervention (week 8) and post-intervention (week 16). The F-test from Wilk’s Lambda test was used analyze changes in EQ-5D over the 16 week period of the study from baseline to post-intervention.

The student t-test was used to compare pre and post exercise heart rate values.

A two-way analysis of variance (ANOVA) was used to determine the mean changes in Kt/V values with respect to exercise intensities over time.

Age, Borg scales, heart rates and Kt/V values are presented as means and standard deviations, while gender is presented as a proportion of the total sample.

95% confidence intervals were used to establish statistical significance ($p<0.05$)

Chapter 4

RESULTS

In this chapter the demographic data and repeated measures results at baseline (week 0), pre-intervention (week 8) and post-intervention (week 16) are presented. Comparisons and differences are also outlined.

4.1 The Sample

A sample of 19 suitable subjects was selected from the total of 34 self-care haemodialysis patients (baseline: n = 19).

Two subjects were approved for kidney transplantation after baseline values were established and were subsequently excluded from the study.

Another subject was admitted to hospital prior to the intervention with a related illness and subsequently died (pre-intervention: n = 16).

Four of the remaining subjects voluntarily withdrew from the study during the first week of exercise.

A total of 12 subjects completed the study (post-intervention: n = 12).

4.2 Demographics

Subject demographic data are summarized in table 4.1 below. Values are Mean (±SD) or as otherwise indicated.

Table 4.1: Demographic profile of study population at baseline (n = 19)

Characteristics	Mean values (± SD)
Age (years)	55.53 (± 11.39)
Dry weight (kg)	74.16 (± 17.2)
Number of women	7
Number of patients with fistulas	15
Primary diagnosis (n)	
Diabetic neuropathy	8
Hypertensive nephrosclerosis	9
Wegener's granulomatosis	1
Alport's syndrome	1
Co-morbidities (n)	
Diabetes mellitus	8
Cardiac history	1
Hypertension	12
Medications (n)	
Erythropoietin	19
β-blockers	13
Angiotensin-converting enzyme inhibitors	12
Ca^{2+} channel blockers	8
α-blockers	0
Fe^{2+} supplementation	18
Dialysis prescription (n)	
2 days per week	5
3 days per week	14
Duration (hours)	4
Blood flow rate (ml/min)	330.53 (± 51.48)
Dialysate flow rate (ml/min)	500
Dialyser: Fresenius HF80(S)	15
Fresenius F 60 (S)	3
Gambro Polyflux 170 H	1
Needle size: 15 gauge	19
Duration of dialysis (months) - Mean	19.6 (± 12.58)
- Median	16

4.3 SCORES

4.3.1 Baseline scores (Week 0)

The baseline Kt/V value for subject 11 was not obtained due to the subject being away at the time of routine blood sampling. The mean Kt/V of 1.70 indicates adequate dialysis for the sample (Kt/V > 1.2).

Table 4.2: Baseline values for dialysis efficacy (Kt/V) and quality of life (EQ-5D)

Subject number (n = 19)	Baseline Kt/V	Weighted EQ-5D index values
1	2.66	1
2	2.0	1
3	2.2	0.710
4	2.1	0.796
5	0.92	0.812
6	1.16	1
7	1.24	0.779
8	1.6	0.691
9	1.5	0.725
10	1.3	0.727
11	N/A	0.725
12	1.2	1
13	2.29	0.848
14	1.22	0.656
15	1.71	0.62
16	1.86	1
17	2.25	0.743
18	1.55	1
19	1.86	0.691
Mean (± SD)	**1.70 (± 0.48)**	**0.82 (± 0.14)**

Comments:

Only subject 6 had a Kt/v less than 1.2. Interestingly, 16 of the 19 subjects scored full health on the weighted index values of the EQ-5D (no physical or psychological problems) despite suffering with ESRD.

4.3.2 <u>Baseline EQ-5D values</u> (Week 0)

In figure 4.1 below, the baseline EQ-5D quality of life values are represented.

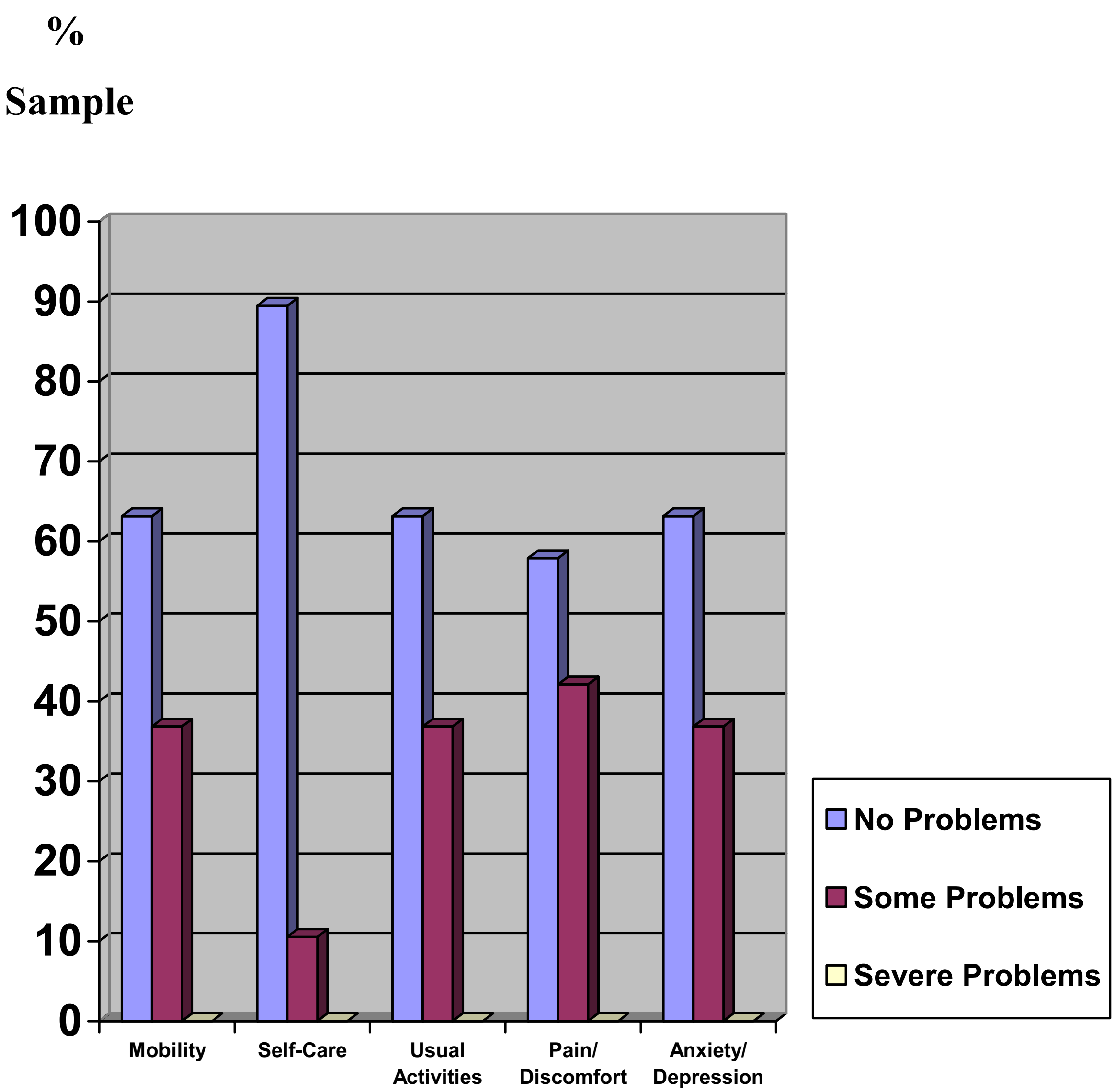

Figure 4.1: Baseline (EQ-5D) quality of life values

Comments:

None of the 19 subjects reported severe problems with any of the dimensions assessed. 89.47% of the subjects reported to have no problems with self-care and 63.16% had no problems with mobility indicating a high level of functional ability and independence among the group.

4.3.3 Pre-intervention scores (Week 8)

The sample size was reduced to a total of 16 subjects after the pre-intervention period of the study due to two subjects going for kidney transplants and one subject passing away due to related illnesses.

Table 4.3: Pre-intervention values for dialysis efficacy (Kt/V) and quality of life (EQ-5D)

Subject number (n = 16)	**Pre-intervention Kt/V**	**Weighted EQ-5D index values**
1	2.36	1
2	1.52	1
3	1.68	0.587
4	1.76	1
5	0.71	0.689
6	1.03	1
7	1.1	0.487
8	1.22	0.195
9	1.21	0.620
10	1.02	0.691
11	1.98	0.725
12	0.97	1
13	1.48	0.796
14	1.08	0.656
15	1.42	0.62
16	1.65	1
17	Excluded – Kidney transplant	N/A
18	Excluded – Kidney transplant	N/A
19	Deceased	N/A
Mean (± SD)	**1.39 (± 0.43)**	**0.74 (± 0.24)**

Comments:

The mean Kt/V remained adequate at 1.39, but had decreased from the initial 1.70 at baseline with six subject's values decreasing below adequate levels (Kt/V < 1.2) All Kt/V values had decreased since the baseline data collection, except for subject 1 (increased by 0.16) and subject 11 (baseline data were missing). The mean EQ-5D weighted index value decreased from an initial 0.82 to 0.74.

4.3.4 <u>Pre-intervention EQ-5D values</u> (Week 8)

Figure 4.2 below presents the pre-intervention EQ-5D quality of life values.

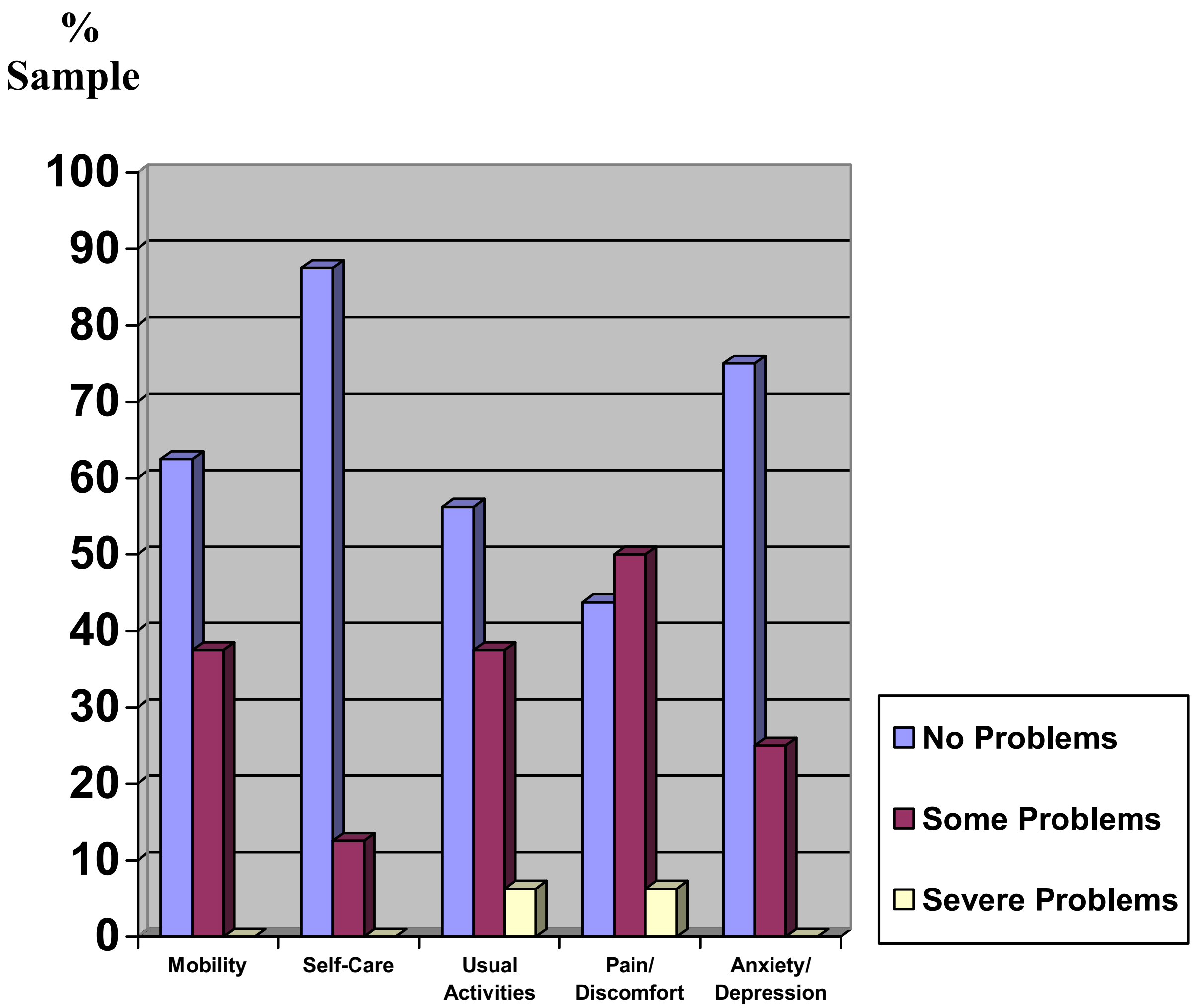

Figure 4.2: Pre-intervention (EQ-5D) quality of life values

Comments:

Of the 16 subjects, 6.25% now reported severe problems with usual activities and pain/discomfort. There was a general decrease noticed in all the dimensions, with larger differences evident in usual activities and pain/discomfort dimensions.

4.3.5 Post-intervention scores (Week 16)

The sample size was now reduced to a total of 12 subjects by the end of the post-intervention period of the study due to four subjects voluntarily withdrawing from the study.

Table 4.4: Post-intervention values for dialysis efficacy (Kt/V) and quality of life (EQ-5D)

Subject number (n = 12)	Post-intervention Kt/V	Weighted EQ-5D index values
1	2.06	1
2	1.78	1
3	1.96	0.691
4	1.93	0.796
5	0.68	0.76
6	1.2	0.85
7	1.1	0.814
8	1.43	0.088
9	1.41	1
10	1.34	0.814
11	2.1	0.725
12	0.97	1
13	Withdrew from study	N/A
14	Withdrew from study	N/A
15	Withdrew from study	N/A
16	Withdrew from study	N/A
17	Excluded – Kidney transplant	N/A
18	Excluded – Kidney transplant	N/A
19	Deceased	N/A
Mean (± SD)	**1.50 (± 0.47)**	**0.79 (± 0.25)**

Comments:

The mean Kt/V remained adequate at 1.50 and had increased from the pre-intervention mean of 1.39. Three of the 12 subject's Kt/V values remained below adequate levels (Kt/V < 1.2). Kt/V values had now increased or remained the same for all except two subjects since pre-intervention. The mean EQ-5D weighted index value increased from the pre-intervention value of 0.74 to 0.79.

4.3.6 <u>Post-intervention EQ-5D values</u> (Week 16)

The post-intervention EQ-5D quality of life values are presented in figure 4.3 below.

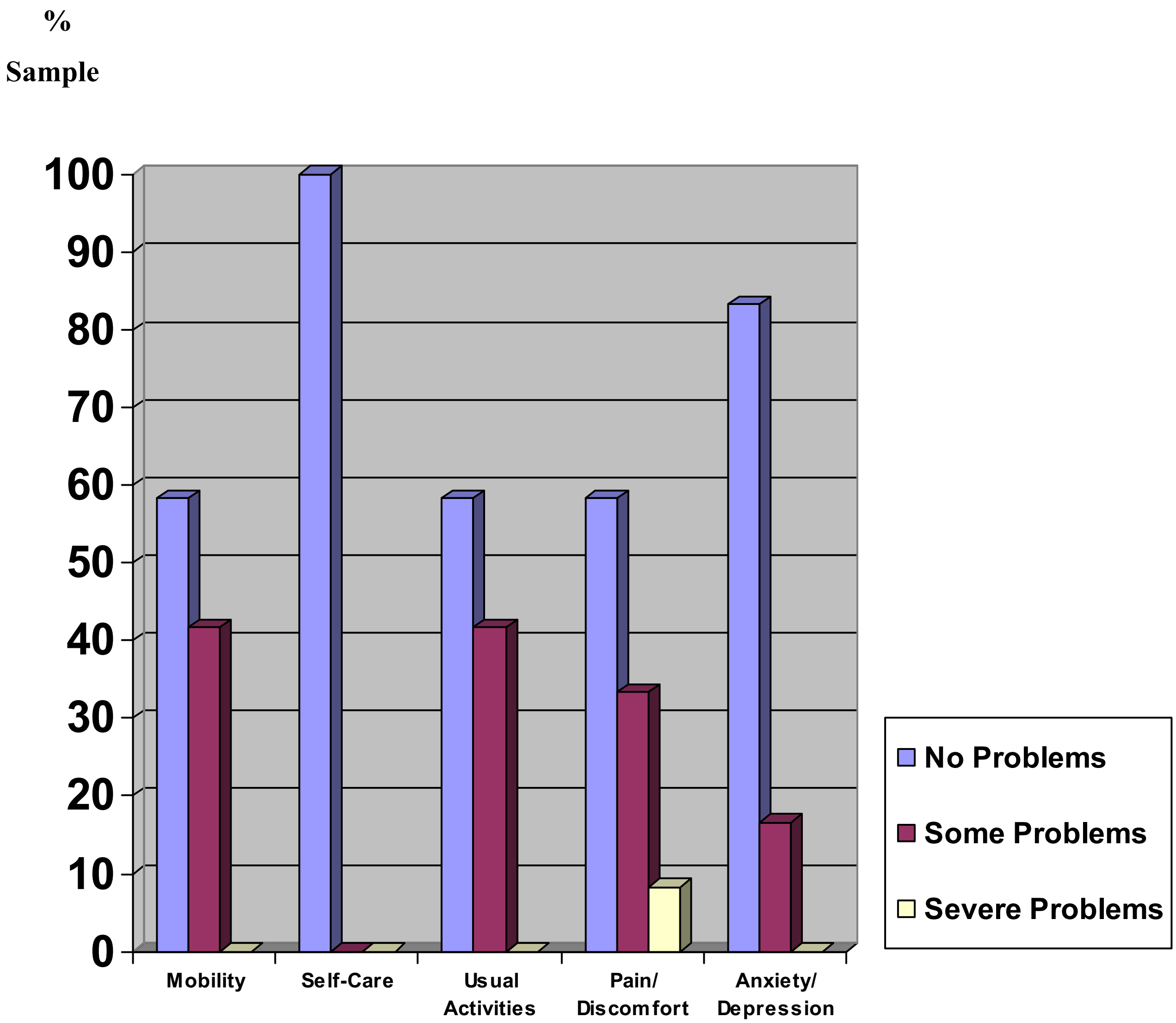

Figure 4.3: Post-intervention (EQ-5D) quality of life values

Comments:

None of the 12 subjects reported severe problems with usual activities. The proportion of patients who reported pain/discomfort had increased slightly from the pre-intervention value of 6.25% to 8.33%. There was a noticeable increase in the self-care dimension with 100% of the subjects now reporting no problems. Anxiety/depression values also improved since pre-intervention and 83.33% now reported no problems with anxiety/depression.

4.3.7 Summary of dialysis efficacy (Kt/V) values

A summary of dialysis efficacy (Kt/V) values are presented in table 4.5 below.

Table 4.5: Summary of dialysis efficacy (Kt/V) values

Subject number	Baseline Kt/V (n = 18)	Pre-intervention Kt/V (n = 16)	Post-intervention Kt/V (n = 12)
1	2.66	2.36	2.06
2	2.0	1.52	1.78
3	2.2	1.68	1.96
4	2.1	1.76	1.93
5	0.92	0.71	0.68
6	1.16	1.03	1.2
7	1.24	1.1	1.1
8	1.6	1.22	1.43
9	1.5	1.21	1.41
10	1.3	1.02	1.34
11	N/A	1.98	2.1
12	1.2	0.97	0.97
13	2.29	1.48	Withdrew from study
14	1.22	1.08	Withdrew from study
15	1.71	1.42	Withdrew from study
16	1.86	1.65	Withdrew from study
17	2.25	Excluded – Kidney transplant	N/A
18	1.55	Excluded – Kidney transplant	N/A
19	1.86	Deceased	N/A
Mean (± SD)	**1.70 (± 0.48)**	**1.39 (± 0.43)**	**1.50 (± 0.47)**

Comments:

The mean Kt/V value decreased significantly from 1.70 at baseline to 1.39 at pre-intervention and then subsequently increased significantly again to 1.50 at post-intervention. This corresponded with a decrease in Kt/V of 18.23% between baseline and pre-intervention ($p = 0.0002$), followed by an increase of 7.91% between pre and post-intervention ($p = 0.04$).

4.3.8. Summary of weighted EQ-5D index values

A summary of weighted EQ-5D index values are presented in table 4.6 below.

Table 4.6**:** Summary of weighted EQ-5D index values

Subject number	Baseline EQ-5D (n = 19)	Pre-intervention EQ-5D (n = 16)	Post-intervention EQ-5D (n = 12)
1	1	1	1
2	1	1	1
3	0.710	0.587	0.691
4	0.796	1	0.796
5	0.812	0.689	0.76
6	1	1	0.85
7	0.779	0.487	0.814
8	0.691	0.195	0.088
9	0.725	0.620	1
10	0.727	0.691	0.814
11	0.725	0.725	0.725
12	1	1	1
13	0.848	0.796	Withdrew form study
14	0.656	0.656	Withdrew from study
15	0.62	0.62	Withdrew from study
16	1	1	Withdrew from study
17	0.743	Excluded – Kidney transplant	N/A
18	1	Excluded – Kidney transplant	N/A
19	0.691	Deceased	N/A
Mean (± SD)	**0.82 (± 0.14)**	**0.74 (± 0.24)**	**0.79 (± 0.25)**

Comments:

A Multiple Analysis of Variance (MANOVA) was used to determine if there was any statistically significant difference between the EQ-5D values for baseline, pre-intervention and post-intervention. The F-test from Wilk's Lambda test was 0.82 and $p = 0.63$, thus suggesting that the values did not significantly change from baseline to post-intervention.

4.3.9 Heart rate values

In Table 4.7 below, the pre and post exercise mean heart rates are represented for each of the eight weeks of the exercise programme.

Table 4.7: Pre and post exercise mean heart rate values

Week of exercise	Pre Exercise Session Mean Heart Rates (± SD)	Post Exercise Session Mean Heart Rates (± SD)
1	77.00 (± 8.41)	78.25 (± 8.87)
2	78.17 (± 10.14)	79.33 (± 9.37)
3	75.33 (± 9.91)	78.00 (± 10.10)
4	75.75 (± 5.30)	78.50 (± 5.78)
5	77.83 (±5.44)	80.75 (± 5.33)
6	78.83 (± 4.17)	80.83 (± 6.66)
7	79.67 (± 7.10)	81.42 (± 8.73)
8	79.92 (± 7.50)	82.00 (± 7.39)

The small difference between pre and post heart rate values corresponded with the low intensity of the exercise sessions. The paired t-test was used to investigate the actual patients who showed statistically significant changes in their heart rate values. Only three of the 12 patients who completed the study showed a statistically significant difference with pre and post exercise heart rates.

4.3.10 Exercise intensity (Borg) values

The mean Borg value during the exercise sessions over the eight week intervention period was 2, indicating that the perceived exertion / intensity of the exercise sessions was "Light". Analysis of post-intervention results showed that exercise intensity had a statistically significant effect on heart rate values ($p = 0.006$).

4.4 COMPARISONS

Comparison of pre and post-exercise heart rates and exercise intensity (Borg) values

Table 4.8: Pre and post-intervention heart rates and exercise intensity values

Exercise intensity (Borg value)	Pre-exercise mean heart rate (± SD) (beats/minute)	Post-exercise mean heart rate (± SD) (beats/minute)
1	79.25 (± 6.25)	86.63 (± 6.19)
2	78.19 (± 7.86)	79.82 (± 7.92)
3	74.09 (± 2.88)	75.45 (± 3.86)

Table 4.8 above demonstrates that the mean heart rate values were lower for subjects who exercised at higher exercise intensities suggesting that subjects with lower resting heart rates were capable of exercising at higher intensities.

Comparison of exercise frequency and changes in dialysis efficacy (Kt/V)

A two-way ANOVA was used to compare changes in scores between the subjects at baseline (week 0), pre-intervention (week 8) and post-intervention (week 16) with respect to dialysis efficacy values (Kt/V) and the frequency of exercise. The mean scores for change over time could then be compared for any statistical significance. Of the 12 subjects who completed the study, five exercised twice a week and the remaining seven subjects exercised three times per week.

Table 4.9: Comparison of exercise frequency and dialysis efficacy (Kt/V)

Source	Partial sum of squares	Degrees of freedom	Mean square	F-value	Prob > F
Time (baseline, pre-test & post-test)	0.25	2	0.12	0.54	0.59
Groups (2 vs. 3 X per week)	0.27	1	0.27	0.12	0.74
Residual	7.11	31	0.23		
Total	7.38	34	0.22		

Comments:

In table 4.9 above, analysis revealed no statistically significant changes in Kt/V between subjects who exercised twice a week and those who exercised three times per week. The sample size was however very small and this is an aspect that warrants further investigation.

Comparative analysis

A comparison of dialysis efficacy (Kt/V) changes was done between the data analysis of only the 12 subjects (n = 12) who completed the study vs. the data obtained from the intention to treat analysis (n = 18 at baseline vs. n = 16 at pre-intervention and n = 12 at post intervention). The results are outlined in the tables below.

Table 4.10: Means procedure outlining intention to treat analysis for changes in Kt/V

Analysis including 18 subjects Kt/V totals		
Variable	**Mean**	**SD**
Baseline (n = 18)	1.70	± 0.48
Pre-intervention (n = 16)	1.39	± 0.43
Post-intervention (n = 12)	1.50	± 0.47
Dry weight in kg (n = 19)	74.16	± 17.20
Flow rate in ml/min (n = 19)	330.53	± 51.48

Comments:

- Statistical analysis of the data in table 4.10 above revealed that Kt/V values decreased by 18.23% (↓) from baseline (week 0) to pre-intervention (week 8) with a mean change of 0.31 ($p = 0.0002$).
- Between the 8 weeks of exercise, from pre-intervention (week 8) to post-intervention, an increase of **7.91% (↑)** was noted in Kt/V values with a mean change of 0.11 ($p = 0.04$).
- Despite this 7.91% increase in Kt/V values during the intervention period, an overall reduction of 11.76% (↓) in Kt/V values was noted between baseline (week 0) and post-intervention (week 16) with a mean change of 0.20 ($p = 0.0009$)

Summary of dialysis efficacy (Kt/V) changes in table 10

Based on the analysis outlined above, when comparing the totals of the 18 subjects at baseline with the 16 at pre-intervention and the 12 at post-intervention, who completed the study, the eight week intervention using the manual compression foot pumps for exercise during dialysis resulted in an **7.91% (↑) increase in Kt/V.**

Table 4.11: Means procedure outlining data analysis (n = 12)

Analysis of only 12 subjects Kt/v totals		
Variable	**Mean**	**SD**
Baseline (n = 12)	1.58	± 0.47
Pre-intervention (n = 12)	1.38	± 0.48
Post-intervention (n = 12)	1.50	± 0.47
Dry weight in kg (n = 12)	77.58	± 20.55
Flow rate in ml/min (n = 12)	335.83	± 33.70

Comments:

- Statistical analysis of the data in table 4.11 above revealed that Kt/V values decreased by 12.66% (↓) from baseline (week 0) to pre-intervention (week 8) with a mean change of 0.2 ($p = 0.001$).
- Between the 8 weeks of exercise, from pre-intervention (week 8) to post-intervention, an increase of **8.7% (↑)** was noted in Kt/V values with a mean change of 0.12 ($p = 0.04$).
- Despite this 8.7% (↑) increase in Kt/V values during the intervention period, an overall reduction of 5.06% (↓) in Kt/V values was noted between baseline (week 0) and post-intervention (week 16) with a mean change of 0.08 ($p = 0.03$).

Summary of dialysis efficacy (Kt/v) changes in table 4.11

Based on the analysis outlined above, when only comparing the data of the 12 subjects who completed the study, the eight week intervention using the manual compression foot pumps for exercise during dialysis resulted in an **8.7% increase (↑) in Kt/V.**

General summary on quality of life (EQ-5D) changes

Analysis on quality of life (QOL) changes using the data obtained from the EQ-5D health questionnaires revealed no statistically significant changes over the eight week exercise period or over the total 16 weeks from baseline to post-intervention. However, noticeable but not statistically significant improvements in self-care ability and a reduction in depression/anxiety scores were observed during this pilot study.

Chapter 5

DISCUSSION

In this chapter the most important findings of this study will be discussed. A study of this nature has not been conducted before, so comparisons will be made with similar studies that have been discussed in the literature review and possible influencing factors on the results will be commented on. The limitations, applicability and relevance of this study will also be discussed and recommendations made for future research. In summary, the aim of this study was to establish what effect the use of a manual compression foot-pump has on dialysis efficacy and the quality of life of patients with end stage renal disease. A total of 12 subjects completed an eight week exercise programme using manual compression foot-pumps. Baseline, pre-intervention and post-intervention Kt/v values were established from routine monthly blood results, and quality of life values were established with the use of the EQ-5D health questionnaire.

5.1 Dialysis efficacy (Kt/V) and exercise

The resultant 7.91% increase in Kt/V noted during the intervention of this study, using manual compression foot pumps during dialysis, is not consistent with the 15% increase reported by Kong et al (1999), who used cycle ergometers, but the intensity of their exercise sessions and the specifications of the exercise subjects were not reported making a direct comparison difficult. The study by Cappy et al (1999) however, also reported fluctuations in Kt/V values during their study, but their fluctuations were not as drastic as the initial 18.23% decrease in this study. They reported Kt/V to increase 3%, decrease 9% and increase 11% at three, six and twelve months respectively resulting in no significant change in overall Kt/V. Their study was however substantially longer in duration (twelve months) than this one and unfortunately they too did not report the exercise intensity and specifications of the subjects who exercised during dialysis.

Parsons et al (2004) were the only other researchers who conducted a similar eight week exercise intervention, using cycle ergometers for exercise. They had an exercise group of six subjects who performed cycle ergometry for 15 minutes per hour, during each of the first three hours of dialysis and found no significant increase in Kt/V. They concluded that the intensity, modality and timing of exercise during dialysis should be altered to result in significant changes. The results of this study were not consistent with their study in 2006, where they modified their 2004 protocol, and conducted a five month intradialytic exercise programme in which their subjects (n = 13, one-group repeated measures) exercised three times a week, for 30 minutes in each of the first two hours of dialysis. They produced an 11% increase in Kt/V at the end of the first month and their results remained impressively high (18% - 19%) for the duration of their programme.

An "intention to treat" analysis was followed because it reflects the reality of the clinical situation. Because of this analysis, a significant decrease in Kt/V of 18.23% in this pilot study between baseline and pre-test was partially due to a reduction in sample size reducing the mean Kt/V values. A comparative analysis of the data of only the 12 subjects that completed the study, revealed only a 12.9% reduction in Kt/V between baseline and pre-test.

5.2 Quality of life

Analysis on quality of life (QOL) changes during this pilot study, using the data obtained from the EQ-5D health questionnaires, revealed no statistically significant changes over the eight week exercise period or over the total 16 weeks from baseline to post-intervention. Noticeable improvements however were observed in self-care ability and a reduction in depression/anxiety scores was noted. This was possibly due to the interest expressed in the patients' well being during the study by the researcher and that the exercise programme was a change in routine that shifted their attention off their illness.

The finding of this study with respect to changes in quality of life was consistent with that of Parsons et al (2004). Despite them using a different instrument (SF-36) to measure

QOL, findings confirmed that the duration of this study was too short to affect quality of life scores. The results of this pilot study population however were contradictory to the findings of Diaz-Buxo et al (2000) who reported that their patients (with a mean age of 53.45 years ±15.31) with ESRD have high rates of self-reported physical disability and are almost unable to perform activities of everyday life. More than 55% of the sample population of this pilot study reported no problems with usual activities and approximately 90% of them had no problems with self-care at the pre-intervention stage and 100% any problems at post-intervention, highlighting the high level of function of this sample. When comparing demographic data of these subjects with that of Parsons et al (2004 and 2006), the mean age of subjects exercising was 55.53 years (± 11.39) and was similar to theirs of 60 years (± 17) in 2004 and 53 years (± 18) in 2006.

5.3 Exercise frequency

Of the 12 subjects who completed the study, five exercised twice a week and the remaining seven subjects exercised three times per week. A two-way ANOVA was used to compare changes in scores between the subjects at baseline (week 0), pre-intervention (week 8) and post-intervention (week 16) with respect to dialysis efficacy values (Kt/V) and the frequency of exercise. The mean scores for change over time were then compared for any statistical significance. Analysis revealed no statistically significant changes in Kt/V between subjects who exercised twice a week and those who exercised three times per week probably because the sample size was so small.

5.4 Other influencing factors

Apart from the period of time of the dialysis sessions and the patients' individual blood flow rates, all the other variables capable of affecting Kt/V changes, namely dialysate flow rate, the dialysers, and the fistula needle sizes, were all kept constant for the duration of the study. Therefore, apart from the unlikely event of blood flow being altered and not properly recorded in the patients' records and treatment times being longer or shorter than the specified four hours, there is no other explanation for the resultant 7.91%

increase in Kt/V during this study other than the exercise intervention, using the manual compression foot-pumps, being effective in causing this change.

5.5 Patients' comments

The majority of the subjects in this pilot study enjoyed the interest and concern expressed in their general well-being. Their adherence to exercise was high and a large number of them reported that they enjoyed the exercise. The female subjects were more enthusiastic than their male counterparts.

The exercise diaries were reportedly slightly confusing for the subjects who exercised twice a week because they were designed to accommodate the larger proportion of the sample who exercised three times a week and therefore had additional space available for the extra exercise sessions.

The four subjects who voluntarily withdrew from the study during the first week of exercise all attended early morning sessions that started at 06:00. One subject had to wake up very early in the morning to get to the clinic in time and was too tired to complete the exercise sessions. The other subjects did not enjoy exercising and were not interested.

The pilot study was conducted in winter and early morning exercise sessions were not always welcomed.

A few patients reported muscular cramps in their legs during the third hour of dialysis confirming the findings reported by Daul et al (2004), that occasionally cases of muscle cramps did occur especially in the beginning of the exercise programme and during the last hour of dialysis.

5.6 Limitations of study

The entire population of self-care dialysis patients at the Flora Clinic renal unit at the start of this study was only 34 in total and after screening, a very small sample was available for participation.

The staff in the renal unit is busy and exercise supervision was difficult at times. Ensuring accurate pre and post exercise heart rates was a challenge because they were taken manually.

As mentioned above, it was not possible to control the dialysis time and blood flow during each session and there is a possibility that one of these parameters could have been altered and not properly recorded which could have influenced the Kt/V values.

The duration of the study was relatively short and the results might have been different had the mean values been compared over a longer period of time.

5.7 Applicability and relevance of study

Exercise during dialysis is essentially non-existent in South Africa; this coupled with financial constraints highlights the necessity for alternatives to expensive cycle ergometers that are commonly used overseas. It is however essential to ensure that cost effective alternatives are clinically valuable and this was the aim of this study.

5.8 Recommendations

In light of the statistically significant changes noted in dialysis efficacy (Kt/V) in this pilot study, it is recommended that a larger study be conducted and the intensity be increased to higher Borg-scale levels for appropriately screened subjects. Exercise sessions with manual compression foot pumps of higher intensities would be better received by patients in the first and second hours of dialysis as they tend to get muscular cramps and become tired during the third hour. The protocol outlined by Parsons et al (2006), in which subjects exercise three times a week for 30 minutes in each of the first two hours of dialysis might be a good benchmark for further studies.

Chapter 6

CONCLUSION

A group of 12 self-care haemodialysis patients participated in a 16 week pilot study and completed an eight week intervention using an exercise programme with manual compression foot pumps. A single group time series design was used and repeated measures of dialysis efficacy (Kt/V) and self reported quality of life values were established. An intention to treat analysis was conducted and the following conclusions can be drawn from this study:

- An eight week exercise programme using manual compression foot pumps appears to be effective in improving dialysis efficacy (Kt/V).

- An eight week exercise programme using manual compression foot pumps is not long enough to result in significant improvements in quality of life, but results in noticeable improvements in self-care ability and a reduction in depression/anxiety.

- There is no statistically significant relationship between changes in Kt/V and the frequency of exercise per week.

- It appears that further research on the effects of manual compression foot-pumps on dialysis efficacy and quality of life would be beneficial.