Universidad CEU Cardenal Herrera

Departamento de Fisioterapia

COMPARISON OF TWO EXERCISE PROGRAMS FOR HEMODIALYSIS PATIENTS, INTRADIALYSIS VS HOME BASED PROGRAM. ABSOLUTE AND RELATIVE RELIABILITY OF PHYSICAL PERFORMANCE TESTING

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LIST OF ABBREVIATIONS

AAS	Adjusted Activity Score
ADL	Activity of Daily Living
ATS	American Thoracic Society
BMI	Body Mass Index
CES – D	Center Epidemiologic Studies Depression Scale
CKD	Chronic Kidney Disease
EPIRCE	Epidemiología de la Insuficiencia Renal Crónica en España
GFR	Glomerular Filtration Rate
HAP	Human Activity Profile
HB	Home based
HD	Hemodialysis
HDL	High Density Lipoprotein
HG	Handgrip
HRQoL	Health Related Quality of Life
ICC	Intraclass Correlation Coefficient
ID	Intradialytic
KDIGO	Kidney Disease Improving Global Outcomes
KDQoL	Kidney Disease Quality of Life
Kt/V	
- **K**	- Urea Clearance in the dialyzer
- **T**	- Time
- **V**	- Volume of distribution of urea
L	Left
LDL	Low Density Lipoprotein

LVH	Left Ventricular Hypertrophy
MAS	Maximal Activity Score
MDC	Minimal Detectable Change
MET	Metabolic Equivalent Task
NSAIDs	Nonsteroidal anti-inflammatory drugs
O.N.T	Organización Nacional de Trasplante
OLST	One Leg Standing Test
PASE	Physical Activity Scale for Elderly
PD	Peritoneal Diaylysis
R	Right
RPE	Rating Perceived Exertion
RRT	Renal Replacement Therapy
S.E.N.	Sociedad Española de Nefrología
SEM	Standard Error of the Mean
SF	Short Form
SPPB	Short Physical Performance Battery
TUG	Timed Up and Go
VO2 max	Maximal Oxygen Uptake
6 MWT	6 Minutes Walking Test
10 - RM	10 Repetition Maximum
↑	Increase
↓	Decrease

CHAPTER 1. INTRODUCTION

The kidney, as an organ from the urinary system, has the following functions: 1) regulation of blood ionic composition, 2) regulation of blood pH, 3) regulation of blood volume, 3) regulation of blood pressure, 4) maintenance of blood osmolality, 5) production of hormones, 6) regulation of blood glucose level and 6) excretion of wastes and foreign substances (1).

Nephrons are the functional units of the kidneys, which are made up of a glomerulus and a tubule. The glomerulus is a set of blood vessels that participates actively in the blood filtration to form urine. This filtration contains small molecules like urea, creatinine, glucose and ions that go to the capsular space (Bowman's capsule) and subsequently to the tubules. In the tubules, water and useful chemicals are reabsorbed as amino acids and ions, while the waste substances and excess water end excreted (1).

Kidney function is often measured by the Glomerular Filtration Rate (GFR), which is defined as the amount of filtration flux from blood to the Bowman's capsule generated at the glomerular capillaries of the nephron. The normal GFR is 90-mL/min/1.73 m2 (1).

DEFINITION AND ETIOLOGY

Chronic Kidney Disease (CKD) is a generic term that defines a set of heterogeneous diseases. It is defined as the abnormalities of kidney structure or when a kidney fails to function due to nephron destruction. It is defined as a slowly progressive and irreversible loss resulting in the body's inability to maintain a metabolic condition and an electrolyte balance, or a reduction of GFR for at least 3 months (2, 3).

The most common etiologies for CKD are the Diabetes Mellitus and high blood pressure. It also may result from chronic glomerulonephritis, pyelonephritis, polycystic kidney disease, autoimmune diseases or traumatic loss of kidney tissue (1, 4).

According to the *Kidney Disease: Improving Global Outcomes* (KDIGO) organization, the GFR is measured to determine at which stage is the disease. We can find different stages of CKD established by the GFR levels (2) (see Table 1.1):

- **Stage 1:** characterized by the presence of renal failure with GFR normal or increased (GFR ≥ 90-mL/min/1.73 m2). Usually there are few symptoms. Medication and lifestyle changes could slow down the disease progression and, depending on the initial causes, could be potentially stopped or reversed.
- **Stage 2:** established by the presence of renal failure associated with a slightly reduction in GFR (GFR between 89 and 60-mL/min/1.73 m2). The diagnosis is incidentally because often the patient does not present symptoms. The CKD in this stage could be potentially stopped or reversed with medication and/or lifestyle changes.

  Stage 3: it is a moderately reduction of the GFR (GFR between 30 and 59-mL/min/1.73 m2). As kidney function decreases, toxic substances start to accumulate in the bloodstream, causing different clinical manifestation related with uremia. Anemia may develop and should be treated immediately. We can find two sub stages:
  - **Stage 3A:** early stage where the GFR ranges between 59 and 45-mL/min/1.73 m2
  - **Stage 3B** or late stage: when the GFR ranges between 44 and 30-mL/min/1.73 m2
- **Stage 4** or advanced kidney failure presents a severe GFR reduction (GFR between 15 and 30-mL/min/1.73 m2). Patients present different symptoms such as nausea, metallic state, uremia breath, anorexia, difficult concentration and nervous system disorders (numbness or tingling in the extremities). In addition, patients may present cardiovascular complications. If so, patients have a high risk of progression to stage 5.
- **Stage 5**: GFR lowers bellow 15-mL/min/1.73 m2. Patients with a stage 5 (KDIGO 5) need a renal replacement therapy (RRT), whether

maintenance dialysis (hemodialysis – HD – or peritoneal dialysis) or a kidney transplant.

Table 1. 1 KDIGO classification established by the Glomerular Filtration Rate (GFR)

Stage	GFR (mL/min/1.73m2)	Description
KDIGO 1	≥ 90	Normal Kidney function but urine findings or structural or genetic trait point to kidney disease
KDIGO 2	60-89	Mildly reduced kidney function
KDIGO 3 - **KDIGO 3A** - **KDIGO 3B**	 45-59 44-30	Moderately reduced kidney function
KDIGO 4	15-29	Severely reduced kidney function
KDIGO 5	< 15	Renal failure

KDIGO: Kidney Disease Improving Global Outcomes

When GFR decreases, there is a reduction of the urine capacity for solutes concentration. At first term, polyuria occurs as a compensation mechanism, but in late stages the kidney losses the capacity of urine excretion. Thus, there is a fluid accumulation. Patients in stages 4 and 5 present high sodium, high phosphor retention and hyperkalemia. Metabolic acidosis occurs in the last stage as a consequence of the lack of capacity to excrete hydronium ions (H+), when bicarbonate decreases. Due to this alteration different complications will appear (5).

EPIDEMIOLOGY

CKD is a worldwide problem. The study of EPIRCE (*Epidemiología de la Insuficiencia Renal Crónica en España* – Epidemiology in Chronic Kidney Disease in Spain), promoted by the S.E.N. (*Sociedad Española de Nefrología* – Spanish Society of Nephrology) and supported by the Ministry of Health, determined the prevalence of CKD in Spain (6). This study collected data from the centralized measurement of serum creatinine in a randomized sample of the Spanish population over 20 years and from the estimation GFR by the Modification of Diet in Renal Disease study (MDRD) formula (7). It was estimated that approximately 10% of the adult population suffer from some degree of CKD, being 6.8% for stages 3-5. There were significant differences regarding to age. The 3.3% of people among 40 and 66 years old and the 21.4% for those over 64 years old suffer from CKD, stages between 3 and 5 (6).

Specifically, 5.4% of the population had a KDIGO 3A, 1.1% had a KDIGO 3B, 0.27% a KDIGO 4 and 0.3% had KDIGO 5. The prevalence in those patients followed by primary care who had high blood pressure and diabetes mellitus, could reach from 35 to 40% (6).

According to study S.E.N. – O.N.T. 2012 (*Sociedad Española Nefrológica – Organización Nacional de Trasplante*, - Spanish Society of Nephrology – National Transplant Organization), there are around 50909 people in renal replacement therapy (25057 patients on dialysis and 25852 patients with renal transplantation functioning) (4).

The prevalence of CKD increases in older population, due to the increasing prevalence of risk factors such as cardiovascular disease, diabetes mellitus, high blood pressure or obesity, and obviously, the early diagnosis. In Europe, it has been established an annual growth rate close to 5% (8).

It is estimated that 40% of the Spanish population that are undiagnosed will die before entering a dialysis program, mainly due to cardiovascular problems. Despite the technical advantages of treatment, survival rate evaluated for dialysis patients is 12.9% at ten 10 years. This could be associated with the risk to suffer cardiovascular complications and a high comorbidity. For these reasons, it is now accepted that CKD is one of the leading causes of death and a public health problem (4).

RENAL REPLACEMENT THERAPY

Renal replacement therapy (RRT) is the therapy that replaces the normal function of the kidney. The RRT is used when the patients are in advanced stages (KDIGO 4 and 5). It includes the hemodialysis (HD), the peritoneal dialysis (PD) and the transplantation.

The HD is the most common RRT. Approximately 91.9% of patients with a CKD diagnosis receive HD treatment (9). It is a process that removes waste products that the kidney cannot remove by itself, and corrects the electrolyte, water and acid-base abnormalities associated with renal failure. It is done by removing blood from the body and filtering it. It requires the use of a semipermeable membrane separating solution from blood to filter out toxic waste substances. Then the filtered blood is returned to the body (10). The HD requires a vascular access (the arteriovenous fistula or a catheter) created to get blood from the body to the dialyzer and back to the body. It is preferably a permanent vascular access and the best option is the arteriovenous fistula, which consists of a subcutaneous anastomosis between artery and vein, usually located at the forearm, although there are two more possibilities (the arteriovenous graft and the central venous catheter) (11). The aim is to achieve a wide venous network with arterial blood, at a blood flux around 200 mL/min. Patients receive the treatment 3 times per week around 3 to 5 hours per session, depending on residual function, body surface, HD technique and patient's disorders (10, 12). To calculate the amount of HD per patient's session it is used the Kt/V, where the:

- K is urea clearance,
- t is length of HD session, and
- V is patient's water volume.

The UK Renal Association and the US K/DOQI have recommended a minimum Kt/V of 1.2. HD treatment is administered for outpatients in the hospital or at home after a training period and home adaptation. This RRT remains ongoing for the lifetime or until a successful transplantation occurs (10,12).

In PD, solute and fluid exchange occur between peritoneal capillary blood and dialysis solution at the peritoneal cavity. The total amount of solute excretion depends on the volume of liquid introduced per day at the peritoneal cavity through an intraabdominal catheter. There is a membrane inside the body called peritoneal membrane, which works as a filter to clear waste and extra fluid. It is a manual and continous technique that consists of introduction of 1.5 to 2.5 liters of dialysis solution every day during four hours, and it is done at home, often at nights, while the patient is sleeping. This technique is specially recommended for those patients suffering ischemic cardio-pathology, children and elderly, diabetics and when troubles with vascular access are present. There are two types of peritoneal dialysis: the continuous ambulatory peritoneal dialysis and the automated peritoneal dialysis (10).

The last RRT is transplantation. Renal transplantation comes from cadaver or from living donor. Despite all patients should be considered for transplantation, it is a surgical intervention with a wide range of risks. In a short-term, patients are at risk of blood clots and infection. In a long-term the risks include diabetes, acute or chronic rejection, infections due to immunosupressor chronic treatment, cancer, high blood pressure, cardiovascular complications, hyperparathyroidism, nephropathy of the transplanted kidney, etc. Polyuria and normalization of nitrogen metabolism occur if the intervention is successful, and a hydroelectrolitic reposition is required (10). Survival of the transplanted kidney is about 90% at the first year, but decreases to 20% 20 years after the transplantation (5).

RISK FACTORS AND COMPLICATIONS

The progression of CKD can be influenced by a number of risk factors. Some of them are modifiable and will allow delay or control the progression of kidney disease, such as proteinuria, high blood pressure, diabetes mellitus, obesity, smoking, anaemia, dyslipidaemia or metabolic syndrome; while there is another group that are not modifiable, such as age, gender, race or degree of renal function (8, 13).

Table 1.2 shows the risk factor for CKD.

Table 1. 2 CKD risk factors According to Martinez-Castelao et al 2014

Susceptible factor that increase the possibilities to suffer CKD	Directly factors that could initiate kidney damage
Advanced age Family history of CKD Decreased renal mass Low birth weight Blacks and other ethnic minorities High blood pressure Diabetes Mellitus Obesity Low socioeconomic status	Autoimmune diseases Systemic infections Urinary infections Nephrolithiasis Obstruction of the lower urinary tract Nephrotoxic drugs, particularly NSAIDs High Blood Pressure Diabetes Mellitus
Factors that could worsening kidney damage and accelerate renal function impairment	**Factors that could increase morbidity and mortality in renal failure situation**
Persistent proteinuria Poorly controlled hypertension Poorly controlled diabetes Smoking Dyslipidemia Anemia Cardiovascular disease associated Obesity	Low dialysis dose (Kt / V) Temporary vascular access for dialysis Anemia Hypoalbuminemia Interconsultation or late referral to nephrology NSAIDs: NSAIDs; CKD: chronic kidney disease

CKD: Chronic Kidney Disease**; Kt / V**: K = urea clearance in the dialyzer; t = time; V = volume of distribution of urea. The resulting figure is used to quantify the adequacy of the dialysis dose**; NSAIDs**: Nonsteroidal anti-inflammatory drugs

Many CKD patients may have one or more comorbidities. Comorbidity is defined as a disease or condition that exists alongside another disease. There is a progressive increase in the risk of cardiovascular mortality between stages 3 and 5 of CKD, regardless of the presence or absence of risk factors. Thus, renal failure affects numerous organs and body systems, presenting a wide variability of clinical manifestations, especially in advance stages of the disease, that significantly influence their general well-being (14,15).

Some of the clinical manifestations that a CKD patient can present are:

Cardiovascular complications

People with CKD are at increased risk of cardiovascular disease, and this is the main reason of morbidity and mortality in dialysis population (13, 16, 17) increasing in 45% of deaths (18). The three primary alterations that we can find in CKD patients are the left ventricular hypertrophy (LVH), atherosclerosis and arteriosclerosis (19 – 23). To be physical inactive, being at dialysis treatment, advanced age and the presence of diabetes, hypertension and dyslipidemia contributes to cardiovascular disease development (17).

High blood pressure is one of the main causes of cardiovascular morbidity and mortality in this population. Between 63 to 86% of CKD patients undergoing HD report high blood pressure. From those, 16% present high values of systolic pressure and 10% high values of diastolic pressure. Hypertension contributes for the development of LVH or the presence of arrhythmias (18, 19, 24,25).

LHV, present in 75% of patients in RRT, is an adaptation resulting from the dysfunction between systolic and diastolic pressure to compensate the increase of workload on the heart, with the objective of minimize ventricular wall stress (26). As a result of the workload over time, there is a development of congestive heart failure, ischemic heart disease (secondary to increased oxygen and poorly coronary filling), hypotension in dialysis or arrhythmias, and in occasions, sudden death (13,18, 27). The presence of LVH is strongly associated with cardiovascular morbidity and mortality in this type of patients (17).

The atherosclerosis is an occlusive disease characterized by hardening, increasing the thickness and the loss of elasticity of arterial walls, resulting from the deposition of lipid material and the chronic inflammatory state. These changes reduce the ability of endothelial cells to maintain vascular homeostasis resulting in lipid and leukocytes infiltration, which provokes an inflammatory response. The deposition of lipid material and the chronic inflammatory responses could result in coronary heart disease, cerebral vascular disease and peripheral vascular disease (17, 18, 28, 29).

The arteriosclerosis is characterized by the dilatation and hypertrophy of large arteries with loss of arterial elasticity and reduced arterial compliance. It is secondary to volume overload and mineral metabolism abnormalities. The consequences are LVH, reduction of coronary perfusion and increased systolic blood pressure and pulse pressure (18).

Hematological complications

Anemia is frequent in CKD and can be diagnosed at any stage but is more common in patients with more severe CKD, especially patients with KDIGO 4 or 5. Renal anemia is normochromic and normocytic (22). The main cause is the inappropriate production of erythropoietin by the kidney. There are other potential causes such as iron deficiency, malnutrition (B12 and folate deficiency) and inflammation associated with kidney disease. As a compensatory mechanism, the body responds with fatigue, dyspnea, increased cardiac output and LVH (10, 22, 30). Anemia does not worsen over time although it may affect the CKD patients' exercise capacity. As a response to erythropoietin therapy, which is associated with cardiovascular benefits, maximal exercise capacity increases and it is associated with decreased cardiac output or left ventricular mass with lower incidence of angina and episodes of heart failure, as well as a better hemodynamic HD session tolerance (31 – 34).

There are other hematological disorders such as platelet disorders with increased number of bleeding and white series, responsible for an alteration in the immune system and increased presence of infections (22, 30).

Musculoskeletal abnormalities

CKD patients present several symptoms, predominantly at lower limbs, such as muscular weakness, fatigue, myoclonus and cramps, that limit their work-related activities or other activities of daily living (35, 36). These symptoms do not only appear in advance stages, but also the literature describes that patients in pre-dialysis stages already present a reduction of muscle strength and endurance (37).

Muscular atrophy is a consequence of uremic neuropathy. It is associated with protein wasting (cachexia), decline vitamin D, acidosis, comorbidity, HD treatment, nutrition intake and sedentary lifestyle. Furthermore, muscle wasting increases as kidney function worsens, contributing to asthenia and to reduction of physical activity (reduced strength and the ability to generate force –myopathy-) and health related quality of life (36). There are multifactorial causes. Muscle atrophy is linked to abnormal structure and function of muscle fibers. Previous studies have shown a morphological and degenerative muscle alteration in dialysis patients, particularly in stages 4 and 5 (35). Morphological studies have shown a reduction of muscle fibers cross-sectional area (38, 39), predominantly affecting fibers type II (anaerobic fibers) (34, 35, 39, 40). Degenerative changes include reduced myofilaments and fiber capillarization and mitochondrial changes associated with neuropathy atrophy (35, 41, 42). Decline in functional capacity and strength is directly associated with morbidity and mortality (42).

Muscle fatigue can occur as a result of failure at one or more sites along the pathway of force production. Central activation failure, impaired neuromuscular propagation, impairment or contractile function, or altered muscle metabolism can contribute to muscle fatigue (43).

Respiratory complications

One of the most frequent dialysis problems in emergency is the presence of pulmonary edema secondary to volume overload or heart failure (44). Other manifestations of renal patients are pleural effusion, respiratory infections and pulmonary metastasis in patients with long evolution calcifications that will be able to develop restrictive lung illnesses (45, 46). Pneumonia is an important cause of mortality in this population (30).

Neurological complications

Chronic renal failure affects both the central and peripheral nervous system due to the presence of uremia (5, 22,30), as a consequence of complication of metabolic complications or from disordered homeostasis. The neurological complications can be restored after transplantation (30). The neurological complications are very common and can be found in the 70% of dialysis patients (19).

A common alteration in these patients is the uremic polyneuropathy characterized to be a peripheral neuropathy that affects symmetrically and distally lower limbs (5, 22, 30). This is secondary to axonal degeneration and demyelination that provokes loss in sensorial and motor capacity. Some symptoms that can appear are paresthesias, painful dysesthesia, ataxia, cramps or muscle weakness (5, 30, 47, 48).

When GFR reaches 10% uremic encephalopathy appears, presenting different symptoms such as headache, fatigue, confusion, impaired consciousness, loss of memory, personality changes, seizure, lethargy, myoclonic twitching of distal muscle groups and, pre terminally, coma (5, 30, 47, 49, 50).

Sleep disorder is a common complain of dialysis patients and it is found in 50% of CKD patients. Insomnia, delayed sleep onset, excessive daytime sleepiness, and frequent arousals and sleep apnea. These can be attributed to the cytokine production, for the cooling mechanism activation followed by a rising body temperature and a paradoxical acidosis (51). Periodic leg movements in at rest and restless legs syndrome are very common alterations too, which is related to iron deficiency, anemia or uremic toxins accumulation (30, 52). The prevalence of restless leg syndrome reach from 20 to 57% of the patients (53)

Metabolic complications

In advanced CKD, the kidney does not have the ability to maintain homeostasis, which is incompatible with life. Renal failure is associated with many problems of metabolic changes that can be attributed to the disease and the dialysis treatment. Pathogenesis of these changes results from changes such as accumulation or deficit of various substances and dysregulation of metabolic pathways (54). There is retention of metabolites in the organism (e.g. creatinine, urea, electrolytes, water) that can lead to different complications that can affect their health related quality of life (54,55, 56).

When GFR decreases to less than 20 to 25% of normal it results in a metabolic acidosis. Metabolic acidosis is a result of a reduced ability to reabsorb bicarbonate, to excrete ammonia, and to eliminate titratable acid excretion (phosphoric acid or sulfuric acid, involved in renal physiology), which is called uremic acidosis (54). Secondary consequences that have been associated with uremic acidosis, are muscle wasting, bone disease, impaired insulin, exacerbation of beta-2 microglobulin, bone disease, abnormalities in growth hormone, hyperlakemia and altered glugoneogenesis and triglycerides metabolism (57, 58).

Hemodialysis contributes to the alteration of carbohydrates metabolism due to the insulin resistance in uremic patients that provokes glucose intolerance (59). Diabetics represent about 35% of all patients on dialysis therapy and those patients that are no diabetics also have glucose intolerance. This is probably because of peripheral insulin resistance (60). The insulin-resistance also can be related to the lack of physical activity, the anemia, the metabolic acidosis or secondary to hyperparathyroidism or vitamin D deficiency (61 – 63). This can also be related to a high cardiovascular morbidity and mortality.

Diabetes Mellitus is one of the most feared complications in kidney disease due to the substantial comorbidities such as blindness or amputation, reaching the mortality rate of 25% of deaths annually (30).

Disorders in lipid metabolism are also present in CKD patients. Triglycerides are elevated because there is a high production of triglycerides rich lipoproteins and also because of dysfunction of triglycerides degradation resulting from insufficient mitochondrial beta-oxidation of fatty acids (54, 64). Additionally, patients present low levels of high-density lipoprotein (HDL) cholesterol, while low-density lipoprotein (LDL) cholesterol levels are often normal. This is frequently associated with atherosclerosis (54).

Osteodistrophy

When kidney function declines, there is a progressive deterioration in mineral homeostasis. As a consequence, there is a disruption of normal calcium and phosphor, and changes in hormones circulating levels. In addition, there is a reduction of vitamin D. When kidney fails, the parathyroid hormone, which promotes phosphor and calcium reabsorption, respond inadequately, resulting in a hypophosphatemia, what has been directly associated to hyperparathyroidism (loss of calcium from bone), and indirectly associated to inhibition of calcitriol (intermediate metabolit of vitamin D). Hyperparathyroidism develops as a result of hyperphosphatemia, hypocalcaemia and impaired renal vitamin D synthesis with reduction in serum calcitriol levels (30).

The hypocalcaemia is secondary to calcium inactivation at parathyroid cells. A reduction of calcium promotes the development of parathyroid gland hyperplasia, which promotes the hyperparathyroidism (10, 65).

The hyperphosthatemia appears when the GFR decreases between 25 and 40%, which leads to decreased serum calcium levels and in turn stimulates the parathyroid hormones secretion. In addition, hyperphosphatemia is associated with resistance to calcitriol at parathyroid glands, resulting in increased parathyroid hormones secretion and resistance of parathyroid hormones on bone (10, 65).

Vitamin D deficiency results from the lack of calcitriol inhibition in parathyroid cells, loss though urine of vitamin D metabolites bound to plasma-binding protein and the tendency to hypocalcaemia. The hypocalcaemia is also associated with a reduced calcium resorption in the intestine by insufficient vitamin D, and partial skeleton resistance to parathyroid hormone to release bone mineral and calcium (65).

These hormonal changes lead to adverse effects on bone physiology and are responsible for the appearance of osteitis fibrosa. The osteitis fibrosa or high turnover bone disease is characterized by increased osteoblast and osteoclast activity and peri-trabecular fibrosis. It is also possible to find low turnover bone disease, which includes osteomalacia (decreased mineralization of the bone matrix), adynamic bone disease (decreased bone turnover that predisposes to hypercalcaemia), osteopenia or osteoporosis (10, 66, 67).

Gastrointestinal complications

Gastrointestinal abnormalities are frequent in CKD patients. Anorexia, dyspepsia, nausea and vomiting are associated with inadequate dialysis or hypotension, leading to decreased caloric intake and malnutrition (22). Diarrhea and constipation are secondary to renal diet, the presence of diabetes mellitus with gastrointestinal involvement or the use of different phosphate binders. Diarrhea is associated with dietary intake or viral disorder, secondary to prolonged antimicrobial therapy, due to infections. Constipation is also related to liquid limitation, low fiber intake fiber present in fruits and vegetables because of the presence of potassium. Constipation predisposes dialysis patients to diverticular disease. Individuals with diverticular disease have more probability to suffer spontaneous colon perforation (30).

Due to platelet dysfunction own uremia, subjects in dialysis treatment have more risk of hiatal hernia, gastritis and ulcer disease gastrointestinal angiodysplasia or upper gastrointestinal bleeding (68,69).

Sexual and reproductive disorders

Both men and women in dialysis treatment have sexual dysfunction. Erectile dysfunction, reduced libido and difficulty in reaching orgasm are present in 70% of male patients (70,71), while women suffer from dysmenorrhea or abnormal menstruation, impaired vaginal lubrication and difficulty to reach orgasm (71) because of disorders at the hypothalamic-gonadal axis leading to decreased levels of estrogen or testosterone (70). These disorders are caused by uremic milieu, anemia, cardiovascular disease, bone disorders, sex hormone disturbances, autonomic neuropathy, hyperparathyroidism and hyperprolactinemia. They occur as a result of medication, physical and/or emotional problems. Pregnancy in dialysis patients is uncommon and pregnant women undergoing hemodialysis present many maternal complications (miscarriage, placental detachment, anemia, infections, premature rupture of membranes, polydramnios, pre-term birth, uncontrolled hypertension, preeclampsia/eclampsia, hemorrhage, need of caesarean and maternal death) (72).

FRAILTY

Frailty is a syndrome among older adults. It is defined as a state of high vulnerability for adverse health outcomes (73) with loss of reserves such as energy, physical ability, cognition or health that gives rise to vulnerability (74, 75). Moreover, decreased resistance to stressors result from cumulative declines across multiples physiological systems (76 – 78).

Frailty may even indicate an increased risk of adverse health effects such as morbidity and mortality reducing patient's health related quality of life (79). Frailty is a result from additive effects of chronic inflammation and acute illness or injures. Also leads to loss of muscle mass and poor physical functioning. Frailty phenotype is assessed by the presence of at least three or more of the following criteria: weight loss, weakness, exhaustion, slow gait, and loss of physical activity level (77). This concept can be applied to CKD patients because this population presents a decreased muscle cross-sectional area, strength, and physical functioning. Systemic inflammation and reduction of protein synthesis also plays a role for muscle wasting and dysfunction (80). In fact, high prevalence of frailty among elderly individuals with mild to moderate CKD has been reported (81, 82), and is more common in individuals with CKD than those without because of the comorbidity and symptoms that present this cohort (83). Frailty risk increases by 2 times in patients with KDIGO 1 to KDIGO 3A and by 6 times in those with KDIGO 3B to KDIGO 5 (84). Frailty is associated with increased incidence of adverse outcome in dialysis patients, increasing the risk of hospitalization and mortality (83, 85).

PSYCHOLOGICAL PROBLEMS IN PATIENTS UNDERGOING HEMODIALYSIS

Patients in maintenance hemodialysis, frequently present emotional disorders, such as anxiety and depression. These two features could be related to survival prediction. Moreover, anxiety and depression affect their health related quality of life (HRQoL), which refers to physical, psychological and social functioning (86, 87).

Depression appears in early stages of CKD but becomes more important in severe stages. It is found from 13 up to 60% of patients undertaking HD (84) and is associated with mortality (89). It is characterized by low mood, loss of interest and pleasure for activities, and low self-esteem (90). Some authors suggest that depression is a strong predictor of HRQoL (87,91).

Anxiety often occurs with depression, considering it as a natural emotion to stress. Anxiety can affect social and family life, work productivity or others. The prevalence ranges from 13 and 50% (90).

In renal failure, depression and anxiety symptoms lead to reduced HRQoL. The World Health Organization defined the HRQoL as the subjective assessment of the impact of disease and its treatment across the physical, psychological and social domains of functioning and well-being (92). The deterioration of HRQoL appears over time in patients with KDIGO 3-5 caused by the presence of fatigue, muscle weakness, restless leg, cramps, itching, nausea and loss of appetite (92). Other authors attributed the HRQoL decrease to different factors such as: 1) physiological alterations secondary to end stage renal disease, 2) comorbidities, 3) biological aging, 4) restrictions in their lifestyle and sedentary behavior imposed by HD (between 12 to 18 hours per week), and 5) loss of psychological and functional health status (93).

PHYSICAL ACTIVITY AND PHYSICAL FUNCTIONING IN HEMODIALYSIS

Physical activity is defined as the movements of the body that are produced by the contraction of skeletal muscles that increase energy expenditure (94). Physical activity is influenced by characteristics and environment of the individual (home, work and transport) (95). A reduction of Physical activity could be as a consequence of uremia, resulting in a reduction of muscle function and fatigue. This reduction is already present in pre-dialysis patients but could increase when the patient is in dialysis. Different studies have demonstrated that patients in maintenance HD have a reduced physical activity compared with healthy age-matched counterparts (96 – 98). It can be associated with increased number of comorbid conditions such cardiovascular problems, anemia, bone disease or nutritional status (97). Physical activity can be measured using the accelerometer, but also through step counters or physical activity questionnaires such as the Human Activity Profile (94).

Physical functioning, defined as individual's ability to perform activities required in their daily lives (94), is determined by physical fitness, sensory function, clinical condition, environmental factors and behavioral factors. We could define physical fitness as the set of attributes (such as cardiorespiratory fitness) that people have or achieve related with the ability to perform physical activity. Cardiorespiratory fitness refers to exercise capacity and is related to the ability of the cardiac, circulatory and respiratory system to supply and use oxygen during physical activity (94, 95). In renal failure, it is known that functional and structural body changes occur, that produce an impairment in mobility and performance of basic tasks, reducing the physical ability to perform activities of daily living, instrumental activities of daily living, and patient's HRQoL (95). Assessment of physical function is valuable in clinical practice to: 1) Identify patients who may benefit from preventive interventions; 2) identify patients at high risk of early death who may be targeted for more extensive evaluation for potential modifiable risks to health and survival; 3) better characterize patients as likely to be in poor health and function; 4) monitor over time to identify a decline in function that may indicate a new health problem; 5) stratify risk for surgery, chemotherapy, or other complex clinical interventions and 6) monitor the effectiveness of clinical behavioral interventions (95).

There are several ways to measure physical functioning: using objective laboratory measures, physical performance testing or self-reported measures. All measures used should be tailored to specific populations and specific characteristics of interest (94).

Objective laboratory measures

The graded exercise test is a tool to measure cardiorespiratory fitness through a maximal exercise performed on a cycle ergometer or incremental treadmill, where the maximal oxygen uptake (VO2 max) is assessed. It requires laboratory settings with specific equipment as it is going to measure physiological impairments. A problem found with this measure is that patients with CKD usually are not able to complete the test due to muscular fatigue (19, 35, 99, 100), possibly due to poor extrerrenal regulation of potassium during and following an incremental exercise test (101). Thus, different functional tests have been developed to measure physical performance in daily life.

Physical Performance testing

Several standardized tests have been developed to evaluate physical performance limitations or tasks encountered in daily life. These tests are easy to assess, are reproducible, do not need a long time to perform them, are not expensive and the patient do not suffer burden (95). There are several tests to measure physical performance, such as the Short Physical Performance Battery, the Timed Up and Go, the One Leg Standing test, the Sit to stand 10 and 60, the handgrip, the one heel rise, 6 minutes walking test or others. Even these tests are not direct measures of cardiovascular fitness, flexibility or strength, they are indicators of physical fitness measures (94). All these test are valid and reliable and have been used in different cohorts, such as dwelling older adults (102 – 106), people with hip fracture (107), in older disabled community dwellers (108), patients with lower amputation (109), patients with chronic heart failure (110), Parkinson disease (111), Alzheimer disease (112) or chronic kidney disease (113 – 117). However, reliability for chronic kidney disease patients has been reported only in some of the tests (the sit to stand 10, sit to stand 30, sit to stand 60, handgrip, one heel rise and 6 minutes walking test) (118, 272).

Another problem that we can observe is that there is not standardized way to assess physical functioning in chronic kidney disease. The identification of reliable physical performance tests for patients with chronic kidney disease undergoing HD would enhance the ability to measure physical function levels and the effectiveness of interventions for both clinical and research purposes (118).

Self-reported measures

Self-reported measures give information regarding disability or restrictive activity participation, through questionnaires such as the physical functioning subscale from the SF-36. The questionnaires can determine the level of perceived difficulty or limitations experienced by patients in different activities (95).

PHYSICAL DETERIORATION IN CHRONIC KIDNEY DISEASE PATIENTS

Even that HD is an advanced technique that prolongs life, this cohort suffers from different disorders such as cardiovascular or musculoskeletal alteration, that contribute to muscle wasting and physical function decline (38, 119), reducing the global survival rate for patients in dialysis treatment by 12.9% at ten years (4). Subjects undergoing hemodialysis have imposed immobilization over 3-4 hours per 3-4 sessions per week (a total of 9-16 hours per week), resulting in low physical activity level. Some of the symptoms that present CKD patients, predominantly at lower limbs, are muscle weakness, fatigue, myoclonus and cramps associated with inactivity. These symptoms limit their work and their daily activities dramatically (35, 36). Over the years, these symptoms contribute to sedentary behavior provoking more deterioration and worsening of health status, leading to disability, loss of independence and increased hospitalization and death risk (119 – 124) but is unknown the rhythm at which physical function deterioration occurs.

Inactivity is associated with more health problems, and in this cohort cardiovascular disease is the first cause of death. Inactivity increases mortality rate by 40% compared to active patients (125).

Low physical activity among hemodialysis patients is associated with physical deterioration, presenting muscle atrophy, lack of energy, neuropathy symptoms or restless leg syndrome (35, 38, 39, 126). As a consequence, patients will present difficulty, limitations or restrictions to perform activities of daily living which could result in disability (126 – 128). Thus, their health related quality of life will decrease.

EXERCISE TRAINING IN HEMODIALYSIS

Historical evolution

Physical activity benefits have been documented extensively in different populations, such as sedentary elderly, frailty elderly, and population with different chronic disease, recommending exercise especially in population with heart failure, obesity, diabetes mellitus or pulmonary problems.

Due to the high comorbidity and mortality that CKD patients suffer, especially because of cardiovascular problems, the sedentary lifestyle and the activities of daily living limitations due to hemodialysis treatment, it is recommended to prescribe exercise in this cohort. According to different clinical nephrology practice guidelines (129 – 131), physical activity has to be promoted in renal failure to avoid cardiovascular risks and to avoid the physical deterioration that the patient suffers during the RRT in their physical capacity (132, 133).

Historically, since the decade of 80s, exercise benefits for patients with renal failure have been studied, being Painter et al 1986 the first clinical trial to prescribe exercise during the hemodialysis treatment in the United States (134). Posteriorly, other countries (Greece, Germany or Sweden) implemented physical exercise as part of the renal treatment (9, 135).

Most of the studies in the field of exercise in patients with CKD undergoing hemodialysis implemented aerobic exercise with moderate or high intensity aiming at avoiding cardiovascular alterations and improving the patient's HRQoL (135 – 138). According to one meta-analysis (135), moderate intensity aerobic programs (between 8 to 24 weeks) result in several benefits for renal patients: positive effects in the graded exercise test (peak oxygen consumption, time and power achieved), quadriceps strength, fatigability, physical function, blood pressure, cross sectional muscle fiber area, capillarization and HRQoL (39, 135, 138 – 142).

By the end of the 90s, programs based on the endurance strength were implemented during HD session, mainly to avoid muscle wasting and the worsening of physical condition. Despite the lack of significant changes, positive effects have been reported on functional capacity (sit to stand to sit test 5, and 6 minutes walking test), lower limbs strength, quadriceps muscle cross-sectional area, and, low to medium effect for the body mass index) (135, 143).

The combination of aerobic and strength programs has been also studied (137, 144, 145). Patients that performed this type of programs had positive effects with no significant changes in the lower limbs strength, and in the systolic blood pressure, positive effects and significant changes in the METS achieved in the graded exercise test, in the ejection fraction during the exercise and in cardiac output during the exercise. However, there were no changes in the power achieved in the graded exercise test. It also has been reported improvement in the HRQoL mental and physical components (135, 137, 146).

We can observe that the number of patients in HD is increasing and patients are older and with major comorbidities. This is caused because the survival rate overall is increasing (6, 8). Thus, elderly HD patients could be unable to participate in these high training programs (148 – 150). Some studies on low – intensity training programs observed improvement in elderly population in maintenance HD (116, 147, 151, 152).

Recently, the neuromuscular electrostimulation has been used in patients with chronic kidney disease undertaking HD resulting in an improvement on the physical function, muscle strength and body composition, being an alternative to prevent muscle atrophy and physical deterioration (153, 154). Virtual reality exercise also has been shown to improve physical fitness, body composition and fatigue in HD patients (236).

Table 1.3 shows the benefits of regular exercise in CKD patients undertaking HD.

Table 1. 3 Benefits of regular exercise participations

Type	Benefits	Potential goals of the program
Aerobic training	↑aerobic exercise capacity (155) ↑VO2 peak (19, 150, 155, 161, 162) ↑exercise duration (155) ↑muscle strength (138) ↑power (138) Improved fatigability (138) ↑ejection fraction (19, 142) ↑systolic volume (19, 142) ↑cardiac output index (19, 142) LVH adaptation (88) ↓arrhythmias (88) ↓antihypertensive drugs (156) ↑arterial stiffness (157) ↑HDL levels (158) ↓LDL levels (158) ↓triglycerides levels (158) ↑insulin resistance (158, 161)	Improved cardiorespiratory fitness Increased submaximal endurance Improved control of blood pressure Weight loss Increased bone health Increased survival

	↓depression (159) ↓anxiety (137, 150) ↓physical and mental component in SF-36 (137, 150) ↓Total body fat (163)	
Resistance training	↑strength (160) ↑functional capacity (160) Muscle hypertrophy (35) ↑fibers type I, IIa, IIb (35) ↑cross sectional area (35,163, 164) ↑endurance (163, 164) ↑power (163, 164) ↑functional activities (163, 164)	Increased lean body mass Improved glucose metabolism Improved ADL Increased bone health Decreased risk of falls
Combined training	↑aerobic exercise capacity (19, 147155, 165) ↑VO2 peak (19, 147, 155, 165) ↑muscle strength (146) ↑functional test (146, 147) ↑ejection fraction (19) ↑cardiac output (19) ↑Time of exercise (19, 155, 165) ↑systolic blood pressure (19)	Improved cardiorespiratory fitness Increased submaximal endurance Improved control of blood pressure Increased lean body mass Increased bone health Increased survival Decreased risk of falls

↑Increase; ↓Decrease; **ADL**: Activities of daily living

Exercise classification according to the training location

The different exercises programs in CKD can be classified according to the location where the intervention takes place, during the HD, in a center in non-dialysis days or at home.

Most of the published studies report exercise benefits during the HD (intradialytic exercise). It is recommended to do the exercise during the first two hours of the HD, when the patient has hemodynamic stability (167 – 169). Usually, to perform aerobic exercise the cycle-ergometer is positioned in the seated or supine position (39, 53,115, 141, 144, 147, 170 – 176) and to perform the strengthening exercises the subject uses weights, elastic bands or balls (114, 115, 174, 177, 178). Intradialytic exercise has been described as safe and with no adverse effects for the patients, having a high compliance and a high adherence to the programs (135). Despite the documented benefits of exercise programs during the HD, most HD units have not introduced this type of treatment as a routine. Different reasons can explain this: lack of patient's interest; lack of knowledge about assessment, exercise implementation and beneficial effects; fear to injuries; lack of qualified professionals to implement exercise in this cohort (such as the physical therapist) in the units and lack of exercise equipment; lack of motivation are some common barriers to engaging in this exercise modality (179 – 183).

Exercise could also be performed in non-dialysis days. This type of exercise can take place in a rehabilitation center under a professional supervision. But, unfortunately, this modality has a high number of dropouts, and participants describe different barriers to complete the program in non-dialysis days, such as transportation difficulty, lack of time in non-dialysis days, changes in medical status, fatigue or too many medical problems (155, 179).

Another alternative to promote exercise in CKD are the home based programs. The benefits are no transportation required, flexibility to do the exercise at any time when subjects consider it is suitable, and they can incorporate the exercise in their daily routine. Konstantinidou et al. (155)

observed a low rate of drop out even that they could not ensure the compliance of the participants (155), but recently Tao et al (184) obtained a high adherence rate. Nurses, in Tao et al (184), conducted a series of educational strategies strengthen participants' exercise adherence. They sat with each patient between 15 and 30 minutes to explain them which were the benefits of doing exercise, explored the possible barriers that they could find at home and tried to find a solution, reach a consensus to set targets and monitored exercise (184). Other home based studies involved only aerobic exercise (185 – 189) or combination of aerobic and resistance exercise with free weights or elastic bands (190), but also results of a supervised home based program (191), or Taichi program (192) have been reported as successful programs.

Exercise during dialysis is described as the best modality to exercise with this kind of patients (115, 166) because adherence in this modality is higher compared with others (155); however, exercise programs are not implemented in most hemodialysis units (193). One of the reasons could be the economic burden. Home based programs could be a solution to implement exercise in CKD at lower cost (166).

HYPOTHESIS

1. **1.** The Short Physical Performance Battery, the One Leg Standing Test and the Timed Up and Go test have high test- retest reliability. Minimal clinical important changes of these tests will be identified.

2. Patients on hemodialysis suffer deterioration over a six months' period of time in functional capacity, strength, physical activity level and health related quality of life.

3. The implementation of a combined exercise program during 16 weeks, either intradialysis or home based, will be beneficial for functional capacity of patients' in maintenance hemodialysis.

4. The implementation of a combined exercise program during 16 weeks, either intradialytic or home based group, will increase the physical activity level.

5. The implementation of a combined exercise program during 16 weeks will improve the health related quality of life of patients in maintenance hemodialysis, either intradialytic or home based group.

6. Adherence to exercise will be higher in the intradialytic group than in the home based group.

OBJECTIVE

1. To examine the relative and absolute reliability of the Short Physical Performance Battery, the one leg standing test and Timed Up and Go and to calculate the minimally detectable change scored for these tests in chronic kidney disease receiving hemodialysis.

2. To quantify the degree of functional deterioration experienced by chronic kidney disease patients undertaking hemodialysis during a six-month period.

3. To compare the effects of 16 weeks intradialytic program versus home based exercise for hemodialysis patients regarding functional capacity.

4. To compare the effects of 16 weeks intradialytic program versus home based exercise for hemodialysis patients regarding physical activity level.

5. To compare the effects of 16 weeks intradialytic program versus home based exercise for hemodialysis patients regarding health related quality of life.

6. To compare the effects of 16 weeks intradialytic program versus home based exercise for hemodialysis patients regarding adherence.

CHAPTER 2. GENERAL METHODS

SAMPLE

Patients with chronic kidney disease undergoing hemodialysis were recruited from three hemodialysis units from Valencia and Terrassa (Spain): Hospital Virgen del Consuelo, Hospital Universitario Doctor Peset and Hospital de Terrassa recruited from September 2013 until April 2015. All patients undergoing hemodialysis were evaluated for eligibility via medical history review and authorization from the patient's nephrologist was given before solicitation of interest and written informed consent. All participants received full verbal and written information about the proposed studies and its objectives before informed consent was obtained.

INCLUSION AND EXCLUSION CRITERIA

The inclusion criteria were receipt of recurring hemodialysis for 3 months or more, they were in a stable condition under their medication, and the absence of acute or chronic medical conditions that would preclude the collection of outcome measure data.

Exclusion criteria were: recent myocardial infarction (within 6 weeks), unstable angina, malignant arrhythmias and any disorder (neurological, respiratory or musculoskeletal) that was exacerbated by activity.

ETHICAL APPROVAL

The study was carried out within the ethical standards set forth in the Helsinki Declaration of 1975. Ethical approval was obtained by the Ethics Committee from *Hospital Universitario Doctor Peset* (CEIC), with the CEIC Code 1/15.

CONSENT

The main researcher talked to each eligible patient after obtaining the medical consent, to explain the project. Each subject had the opportunity to ask any question.

OUTCOME MEASURES

Demographic and clinical data were collected from the medical history and included: Age (birth date); Gender (male or female); Body Mass Index (BMI), calculated using the standard formula $BMI = \frac{Mass\ (kg)}{Height\ (m)^2}$; Dry weight; Height; Time on hemodialysis (in month); Cause of kidney disease; Blood pressure; Hemoglobin level, albumin level, creatinine level: measured routinely monthly and the Charlson comorbidity scale.

The Charlson comorbidity scale is a widely used comorbidity Index. It contains 19 issues (diabetes with diabetic complications, congestive heart failure, peripheral vascular disease, chronic pulmonary disease, mild and severe liver disease, hemiplegia, renal disease, leukemia, lymphoma, metastatic tumor and acquired immunodeficiency syndrome), and each of which was weighted according to their potential influence on mortality (194).

FUNCTIONAL TESTS

All the tests were performed on a dialysis day immediately before the HD sessions and in the same order. The whole procedure is detailed in APPENDIX 2. INSTRUCTIONS – SCRIPTS –.

SHORT PHYSICAL PERFORMANCE BATTERY (SPPB)

The Short Physical Performance Battery (SPPB) is a test that assesses lower extremity, which includes objective performance-based measure of balance (side-by-side, semi-tandem and tandem), gait speed 4 meters and strength (five chair stands). Each component was scored from 0 to 4 and when added yielded SPPB scores between 0 (poor) and 12 (best) performance (195).

To test standing balance, the participants were asked to attempt to maintain their feet in the side-by-side, semi tandem (heel of one foot beside the big toe of the other foot), and tandem (heel of one foot directly in front of the other foot) positions for 10 seconds each. The subjects were given a score of 4 points if they could hold the three positions for 10 seconds. If they were able to maintain the side-by- side standing and the semi tandem position for 10 seconds and maintain between 3 or 9 seconds the tandem position they were given 3 points. A score of 2 points were given when they were able to hold the side-by-side position and semi tandem for 10 seconds but unable to maintain tandem position for more than 2 seconds. A score of 1 point were given when the patient only was able to maintain side-by-side position for 10 seconds but unable to hold semi tandem and tandem position (195).

To test gait speed, we asked the patients to walk at their normal pace a 4 meters' distance. The participants were scored according to quartiles for the length of time required. The time of the faster of two walks was used for scoring, as follows: ≥ 5.7seconds, a score of 1; 4.1 to 5.6 seconds a score of 2; 3.2 to 4.0 seconds a score of 3; and ≤ 3.1 seconds a score of 4. Participants were asked to walk without their usual aids, however, those who could not walk without aids could use them (196).

Finally, to test strength, subjects were asked to fold their arms across their chests and to stand up from a sitting position once; if they successfully rose from the chair, they were asked to stand up and sit down five times (STS-5) as quickly as possible. Time stopped when the participant stood up for the fifth time. Quartiles for the length of time required for this measures were used for scoring as follows: ≥ 16.7 seconds, a score of 1; 13,7 to 16.6 seconds a score of 2; 11.2 to 13.6 seconds a score of 3; and ≤11.1 seconds a score of 4 (196, 197, 198). The test was performed with a standard chair without armrests. Participants can be classified as severe, moderate, mild or minimal limitations based on their SPPB scores (see Table 2.1) (197).

The SPPB has been found to be a reliable tool in dwelling older adult (ICC=0.82) (102), and in older women (ICC=0.88 – 0.92) (103). In addition, researchers have calculated its minimal detectable change in older adults. The Standard Error of the Mean (SEM) was 1.42 points (104) and Guralnik et al (195) concluded that 1 point change in SPPB score led to meaningful differences in the risk for future mortality and incident disability.

Table 2. 1 Classification of limitations based on Short Physical Performance Battery Score. Classification by Guralnik et al. (197)

Score	Classification
0-3	Severe limitation
4-6	Moderate limitations
7-9	Mild limitations
10-12	Minimal limitations

ONE LEG BALANCE TEST (OLST)

To perform the one leg standing test (OLST) the participants were allowed to choose their preferred leg to complete the test and they were permitted to use the other leg if they were having pain or other symptom in the first leg. Subjects' eyes were open, and their arms were allowed to move freely to maintain balance (199). Participants, who requested help to assume testing position, were permitted to use the researcher's arm to steady themselves before start the time trials (200). All subjects wore shoes (199).

The subjects were instructed to try to maintain one leg stance, in a unipedal stance position, for as long as possible. The raised foot had to be near from and not touching the ankle of their stance limb. The test was considered normal if the one leg standing time reached 45 seconds. The reason why it was considered 45 seconds was because Briggs et al (200) felt that a limit of 45 seconds would allow for more normal distribution of times.

The procedure was repeated three times and each time was recorded on the register sheet if the maximum balance time was not reached in either of the first two trials. During each trial the subjects were verbally encouraged to maintain one leg stand position for as long as possible and to prevent falls because of loss of balance the investigator stood near the subject all the time. The best time of three trials was recorded for data analysis (199).

Time was kept with a digital stopwatch and started when the participant raised the foot from the floor or the hand from the researcher's arm. The test concluded when: (1) the participant used their arms to touch the wall, or the investigator (100); (2) if the raised foot touched the ground (199, 200); (3) if the raised foot supported weight (200); (4) if the subject moves the foot which was standing or (5) when time arrived to 45 seconds (199).

OLST has been shown to be a good predictor of falls (100) and ICC has been calculated in different populations with different procedures. For elderly African Americans population, using as maximum time 30 seconds with eyes open, the ICC was 0.60 seconds (105), while in the ICC in elderly population is 0.86 with a maximum time of 30 seconds and the $MDC_{95}$is 24.1 seconds (108). The ICC in people with hip fracture in the affected leg the ICC was 0.75 seconds with a $MDC_{95}$is 10.7 seconds, while in the non-affected leg the ICC is 0.83 and the MDC_{95} is 5.5 seconds using as maximum time of 30 seconds with eyes open (107); and in patients with lower limb amputation the ICC is 0.87 using a maximum time of 60 seconds to do the test with eyes open and the MDC_{95} is 2.74 seconds (109).

TIMED UP AND GO (TUG)

The Timed Up and Go test (TUG) is a simple and valid method to assess functional mobility (201 – 203). The material required is a stopwatch, a standardized armchair and a cone.

Subjects are asked to rise from the chair, walk three meters away, turn the cone, walk back to the chair and sit down again. The verbal instruction was: "Stand up from the chair without use the arms, walk three meters from the front edge of the chair as quickly and safely as possible, turn back the cone, walk back and sit down to the chair". We recorded the time taken to perform it (201). Participants were allowed to wear their regular footwear, and use walking aid if needed. The stopwatch was started on the "go" and stopped when fully sitting position that back against the backrest was reached again. The time taken to complete the test was measured in three consecutive trials and the fastest time measured in seconds was used (202 – 204). The first trial aimed at the subject to become familiar with the test. Between the three trials was a 30 seconds rest time if needed (2013). According to Podsiadlo et al (201) we can divide participants into three groups depending on the time taken to perform the TUG: (1) those who took less than 20 seconds are considerate independent in basic transfers, (2) those who complete the test between 20 and 29 seconds and, (3) those people who needs 30 seconds or more who tend to be more dependent; and Cook et al (205) defined low risk of falls if the TUG was < 15 seconds.

The TUG has shown excellent test-retest reliability (ICC=0.99) in older adults (201). Moreover, research has shown that individuals with a non-history of falls are faster on the TUG than those with falls history across variety of population including older adults (204), individuals with chronic obstructive pulmonary disease (2006), adults with spastic cerebral palsy (202) and women with vertebral fractures (207).

SIT TO STAND TO SIT 10 AND 60 (STS10/60)

Both tests are nonspecific, are simple, inexpensive, rapid and reproducible (208) and are included in previous renal researches in the battery of tests (114, 118, 140, 160, 209). To perform the test only was needed a stopwatch, a standardized chair which was backed up against a wall to minimize the risk of falling.

The Sit to Stand 10 (STS-10) indirectly quantifies lower extremity muscle strength in patients with lower extremity weakness. It measures the time in seconds that the person required to perform 10 full and consecutive repetitions of getting up and sitting down from a standard chair. The test starts and finishes at the sitting position crossing their arms on their chest with the back against the chair. Subjects were instructed to perform the task “as fast as possible”. Participants were allowed a practice trial before the beginning of test (118).

The Sit to Stand 60 (STS 60) was performed after the STS-10. The start and end position is the same as the STS-10. The STS-60 consists of measuring the number of repetitions of standing up and sitting down from the standard chair achieved in sixty seconds. It has been used as a surrogate index of muscle endurance. Each repetition started and finished at the sitting position, and if a participant was standing when the time was over, it was considered half a repetition. Participants were allowed to stop if rest was needed and to continue performing the task until the 60 seconds were over (118).

The STS-10 was measured first and the STS-60 was performed 10 minutes later, when the heart rate and blood pressure had decreased to baseline levels.

The test-retest reliability of the STS-10 and STS 60 were excellent in patients undergoing hemodialysis (ICC=0.88 and ICC= 0.97 respectively) and the MDC for the STS-10 was 8.4 seconds while for the STS-60 was 4.0 repetitions (118).

HAND GRIP STRENGTH DYNAMOMETER (HG)

The Jamar hydraulic hand dynamometer (JAMAR Sammons Preston Rolyan, Chicago, Illinois, USA) was used to measure the amount of strength developed by each hand (210, 211). This dynamometer had adjustable grip for hand size. The participants were instructed to squeeze the Jamar progressively and to apply as much handgrip pressure as possible. The patient should be seated in a chair without arm rests, with knee flexion at 90º with their feet on the floor; the shoulder should be adducted and neutrally rotated, elbow flexed at 90º and the forearm and wrist over a table in neutral rotation with the wrist positioned at 0-15º ulnar deviation (211). The patient was instructed to maintain the elbow in the table all the time, and not to lift the shoulder while he or she was squeezing the device. According to Mathiowetz et al (211), the handle was in the second position counting from proximal. Hand dominance was determined by asking, “Are you right handed or left-handed?” and it was register in the sheet register. Also the test started with the dominant hand. The instructions for the patients were “I want you to hold the handle like this and squeeze progressively to squeeze as hard as you can”. Subjects had to squeeze for three seconds. The test was repeated two more times with the same instructions with an interval of fifteen seconds to avoid muscle fatigue. The score was recorded for each squeeze and then the device zeroed for the next attempt. For each strength test the scores of three successive trials were recorded and then we measured the non-dominant hand and the maximum score for each hand was used for analysis.

This test had been shown test-retest reliability by Mathiowetz et al (211) (ICC= 0.822) in general population. Also it has been shown test-retests reliability in patients with CKD being the MDC = 3.4 kilograms for dominant and non-dominant hands with an excellent ICC (ICC = 0.96 for dominant hand and ICC = 0.95 for non-dominant hand) (118). Moreover, the handgrip has been also shown to be an appropriate predictor of renal outcomes in non-dialysis CKD patients (212), functional limitations, disability, prolonged hospitalization and mortality in older adults (211).

ONE LEG HEEL RISE

The triceps sural is weak in pre-dialysis stages (213). The weakness of this muscle could contribute to an altered gait pattern (214). Therefore, the one leg heel rise test has been used in previous studies to measure functional strength of the calf muscles in patients undergoing hemodialysis (118).

This test consists of repeated eccentric and concentric muscle action and reflects endurance rather than strength in the plantar-flexor muscles. To perform it subjects wore no shoes. To keep the rhythm at a rate of seconds we used a metronome (214).

Participants were asked to start touching the wall with their fingers, with arms in abduction. The back could not touch the wall. Individuals were asked not to push their arms against the wall and the thereby shifting their weight. Before the test, participants were asked to maintain balance in that position while standing on one leg. The contralateral foot was held just above the floor. Participants were allowed to have one trial to become familiar with testing procedure and were instructed to lift the heel as high as possible at the metronome rhythm until no further heel rises could be performed due to exhaustion. The test finished if the participant leaned or pushed against the wall or their knees were flexed, according to the examiner's observation. Also, they were instructed to perform a maximum of 25 repetitions because is considered the average number of repetitions performed by healthy subjects (118; 214, 215). They performed the test with both legs and we recorded the degree of difficulty determinate by Borg Scale Rating of Perceived Exertion (RPE) (APPENDIX 5. THE BORG RATING OF PERCEIVED EXERTION SCALE).

This test has been shown test-retest reliability to use as part of functional battery tests in CKD patients (ICC right leg = 0.97; ICC left leg = 0.94) and the MDC in the one leg heel rise was 3.7 for the right leg while in the left leg was 5.2 repetitions (118).

THE 6 MINUTES WALKING TEST (6MWT)

The six minutes walking test is a practical, simple, functional and self-paced walk test that is widely used in pulmonary disease, but also is frequently used in patients with renal disease to measure the impact of renal rehabilitation (37, 114; 146, 150, 160, 164, 187, 209). This test measures the longest distance that a patient can walk on a corridor, hard surface in a period of 6 minutes. The 6MWT is used because is easy to administer, is inexpensive to perform, is well tolerated and reflects daily activities. According to the American Thoracic Society (ATS), it evaluates the global and integrated responses of all the systems involved during exercise. We used the ATS guideline standardization (216). It is a submaximal test of aerobic capacity, and reflects the functional exercise level for daily physical activity.

The walking course was set in a 20 or 30 meters' corridor (depending on the hemodialysis unit) and marks were taped on the floor every 2 meters. Participants were allowed to use any walking aid that they used usually in daily life. Adults were instructed to walk the longest distance possible in six minutes by walking continuously the 20-30 meters indicated on the floor, turning around at the final mark without stopping, and covering as much ground as possible (217), the verbal instruction was "Walk as far as possible for 6 minutes, but do not run or jog” (216). They could stop if needed and restart later. Heart rate and blood pressure were measured immediately before and after the test. We registered the distance covered (in meters) and the degree of difficulty determined as the RPE at the end of the test.

The 6 MWT is considered to be a better indicator of the ability to perform activities that resemble those of daily life, such as walking, than physiological exercise capacity testing in patients with heart, respiratory failure and chronic renal failure. This test appears as the best measure of exercise endurance to assess maximal exercise capacity compared with laboratory-based environment which involves techniques and tasks which people are not always familiar (118). Furthermore, the ATS Committee on Proficiency Standards for Clinical Pulmonary Function Laboratories describes this test as a measure to predict, not only the functional status of the patients, as well as a morbidity and mortality predictor (216).

In spite of being a useful test, there are some absolute contraindications such as unstable angina during the previous month or myocardial infarction during the previous month. In addition, some relative contraindication such as heart rate more than 120, a systolic blood pressure of more than 180 mmHg, and a diastolic blood pressure of more than 100 mmHg.

It has shown good reliability in adults with chronic kidney disease (ICC=0.94) and the MDC in this test was 66.3 meters (118).

THE10 REPETITION MAXIMUM

The 10 repetition maximum (10-RM) method can be defined as the maximum amount of weight lifted ten times. Subjects were seated in a chair with the back against the backrest with 90º of hips and knees flexion. The participants were asked to extend both knees from standardized position 90º flexed knees until 0º keeping limb horizontal, with attached adjustable weights applied to the ankle (218). The rhythm for this exercise was two second of concentric contraction, two seconds of isometric contraction and four seconds of eccentric contraction, without pauses between each repetition. The initial weight was standardized among subjects and when the weight was successfully lifted the weight for the next trial was incremented by 0.5 to 2.5 kg (219) and asking the effort for that exercises by the RPE. Between one to five minutes' recovery was allowed between each trial to avoid muscle fatigue (219). The test stopped when in the last trial they perceived and effort of 13 – 15 in the RPE, meaning that the participant could no longer lift the weight to complete one more full knee extension with both legs together. The test was performed every two weeks to adapt the weight lifted during the exercises to the increased strength (220).

QUESTIONNAIRES

Several questionnaires were used to measure physical activity level, depression and health related quality of life. All the questionnaires were filled in the unit during the HD session with assistance of a researcher.

PHYSICAL ACTIVITY QUESTIONNAIRE

HUMAN ACTIVITY PROFILE (HAP)

The Human Activity Profile (HAP) is a questionnaire created to assess general physical activity. It was originally developed to measure quality of life in obstructive pulmonary disease by Fix et al. (221), though it has been also used in ESRD (221) and renal transplantation (222).

It consists of a list of 94 self-reported activities. Each item represents a common activity requiring a known amount of average energy expenditure and is ranked in ascending order of level of energy required to perform each activity. The first item is #1 "getting in and out of chairs or bed (without assistance) to #94 "jogging 4,8 km within 30 minutes" The subject has three possible answers: (1) still doing this activity; (2) Have stopped doing this activity; (3) Never did this activity. To evaluate this questionnaire is needed the Maximal Activity Score (MAS) and the Adjusted Activity Score (AAS). The MAS is the numeral identifying the activity with the highest oxygen consumption requirement that subject still performs while the AAS is the difference between the MAS and the number of less demanding activities the subjects has stopped performing. The AAS give us a better estimate of the range of activities performed and the presence of impairment. Thereby, HAP scores represent the range of activities a participant is performing rather than actual activity performed over a given period. For example, a person who is still washing the clothes without assistance (#42) would have MAS of 42. If this person has stopped performing eight activities that are less strenuous than wash the clothes without assistance the AAS would be 34 (221).
Depending on the AAS the patients can be classify as impaired (AAS less than 53), moderately active (AAS 53-74) or active (AAS greater than 74) (221) (Table 2.2).

Table 2. 2 Activity Classification according to the Human Activity Profile by Fix et al. (221)

Classification	AAS
Impaired	Less than 53
Moderately Active	53 – 74
Active	Greater than 74

This questionnaire has been found to be valid for patients with end stage renal disease (223).

PHYSICAL FUNCTION QUESTIONNAIRE

PHYSICAL ACTIVITY SCALE FOR THE ELDERLY (PASE)

The Physical Activity Scale for Elderly (PASE) is a questionnaire that consists of assessing physical activity reported in the previous week. The subjects reported the amount of time they spend doing a specific type of activity categorized as leisure time activity, household activity, and work-related activity, using activities that are commonly performed by elderly. In the questionnaire, each subject had to report the number of days per week the activity was performed and then the number of hours per day. There are 12 types of activities. For each activity is assigned a weight that is derived from a sample of 277 older adults using a combination of accelerometer data, and metabolic equivalent task (MET) values from daily activities. The total score was recorded as the sum of the amount of time that the person spent in each activity (hours per week) multiplied by the weight designed to each activity (224).

This questionnaire has been shown to be valid for patients with chronic kidney disease (223).

SYMPTOMS OF DEPRESSION

CENTER FOR EPIDEMIOLOGIC STUDIES DEPRESSION SCALE (CES-D)

The Center Epidemiologic Studies Depression Scale (CES-D) is a self-reported questionnaire designed to measure the depressive feeling and behaviors experienced during the previous week in the general population (225).

This questionnaire consists of 20 items that include depressed mood, feelings of guilty and worthlessness, feelings of helplessness and hopelessness, psychomotor retardation, loos of appetite, and sleep disturbance. The score range from 0 to 60 points. Higher scores indicate more symptoms, and a person with 16 points or higher are considered at risk for depression in the general population (226). The patient can answer: Rarely or none of the time (less than 1 day) score by 0 points each; some or a little of the time (1-2 days) scored by 1 point each; Occasionally or moderate amount of time (3-4 days) scored by 2 points each; and most or all of the time (5-7 days) scored by 3 points each (225).

HEALTH RELATED QUALITY OF LIFE

KIDNEY DISEASE QUALITY OF LIFE– 36 (KDQoL – 36)

The Kidney Disease Quality of Life – 36 is a self-reported questionnaire, which measures health related quality of life in patients with chronic kidney disease undergoing dialysis in five subscales divided in: The Short Form – 12 (SF – 12) that includes the (1) physical and (2) mental component -12items; (3) Symptoms and Problems – 12 items –; (4) Burden of Kidney Disease – 4 items –; and (5) Effects of Kidney Disease – 8 items – (227, 228). It has a total of 36 questions. Scores of the different subscales were calculated according to the KDQoL – 36 scoring program (227). All measures were scored on a range from 0 to 100 points. Higher scores indicated better health related quality of life.

This questionnaire has shown reliability and validity for this population (227), and also specifically for the Spanish version presenting an ICC between 0.62 and 0.77 for each dimension (229).

CHAPTER 3. INTERVENTION

INTERVENTION

Both exercise programs lasted 16 weeks (4 months) and were undertaken three times per week. Both programs consisted of three phases: warm up, the main part and cool-down. All participants were informed about the importance, the benefits and the risk to do exercises in chronic kidney disease.

EXERCISE DURING DIALYSIS. INTRADIALYSIS EXERCISES PROGRAM

Participants exercised three times per week and each exercise session was supervised and assisted by a physical therapist during the first half the HD session (usually during the first two hours of the treatment to maintain a good hemodynamic tolerance). All exercises were performed on a seated or supine position, depending on the HD treatment position. Heart rate and blood pressure were monitored continuously during the training session, measured every fifteen or thirty minutes depending on how the nurse programmed the HD machine. The weight to perform the strengthening exercises was set every two weeks by the 10 – RM, maximal weight that could be lift 10 times (explained in CHAPTER 2. GENERAL METHODS).

WARM-UP AND COOL-DOWN

The session started (warm-up) and finished (cool-down) with five minutes of passive stretching exercises for lower limbs, including assisted stretching of triceps sural, hamstring and external rotator muscles. Every position was assisted by the physical therapist and was kept for approximately 20 seconds per leg and was repeated twice.

The triceps sural stretching consisted of a maximum ankle dorsiflexion with knee extended (Figure 3.1).

Figure 3. 1 Triceps sural stretching in supine position

The hamstrings stretching consisted of the elevation of the lower limb by flexing the hip while the knee remained extended (figure3.2).

Figure 3. 2 Hamstring stretching in supine position

The hip's external rotator muscles stretching consisted of internally rotating the hip, making circles with ankle, knee and hip flexed (Figure 3.3).

Figure 3. 3 Hip's external rotator muscle stretching in supine position

MAIN PART

The main part consisted of five progressive isotonic and isometric resistance exercises that specifically targeted major lower limbs muscle groups. It also included cycling.

The first exercise consisted of extending one knee from a standardized position 90º flexed knee until 0º keeping limb horizontal, with attached weights applied to the ankle. The exercise timing was two seconds of concentric contraction, two seconds of isometric contraction and four seconds of eccentric contraction, without pauses between each repetition (114) (Figure 3.4). The weight was determinate by 10 RM. Progression was achieved by increasing the weight every two weeks, around 0.5 to 2.5 kilograms. Participants performed 1 set of 10 repetitions and progressed until 15 repetitions of each exercise.

Figure 3. 4 Quadriceps exercise in supine position with weight

The second exercise consisted of a unilateral extension of the hip, knee and ankle (triple extension) against an elastic band, starting from a standardized position of 90º of flexion in the hip, knee and ankle (114) (Figure 3.5). The elastic band was fixed at metacarpal heads. The exercise timing was two seconds for extending hip, knee and ankle and two second for flexing these three joints. Progression was achieved by changing the color of the band or adjusting a double elastic band. Participants performed 1 set of 10 repetitions and progressed until 15 repetitions of each exercise.

Figure 3. 5 Triple extension exercise in supine position

The third exercise consisted of an eccentric exercise for triceps sural with an elastic band fixed at metacarpal heads level (Figure 3.6). Subjects had to make an ankle extension in one second and an ankle flexion in two seconds. Progression was achieved by changing the color of the band or adjusting a double elastic band (114). Participants performed 1 set of 10 repetitions and progressed until 15 repetitions of each exercise.

Figure 3. 6 Triceps sural exercise with elastic band

The next two exercises consisted of two isometric exercises for hip adductors and hamstring muscles (Figure 3.7). Subjects were asked for a bilateral maximal contraction from a 90º flexed hip, bended knee and ankle in the seated position. For the adductors isometric contraction, the subject had a ball between knees and for the hamstring isometric contraction the ball was between heels and the chair or bed (depending on patient's position). If the subject was in supine position, the starting position was with extended leg. They had to maintain the contraction for three seconds and progression was achieved by increasing contraction time up to six seconds. Proper breathing technique was emphasized during all exercises to avoid Valsalva maneuver, as recommended by previous research (230). Subjects performed 1 set of 10 repetitions and progressed until 15 repetitions of each exercise.

Figure 3. 7 Hamstring isometric in supine position

The intensity for all the exercise was adjusted by the degree difficulty according to the Borg Scale Rate of Perceived Exertion (RPE) (APPENDIX 5. THE BORG RATING OF PERCEIVED EXERTION SCALE) at level between 12 and 15. Participants did not feel the exercise "somewhat light" (not less than 11 at the RPE) or "hard" (no more than 15 at the RPE) (114).

After these strengthening exercises, the aerobic exercise session consisted of cycling (cycle ergometer Mottomed Letto), and the position was adapted according to the subject treatment position, allowing cycling in seated or supine position (Figure 3.8). Intensity was adjusted also by the RPE. Thus, if the participant felt the exercise as light (11 or bellow in the RPE) the intensity was increased through resistance or time. On the other hand, if they indicated the exercise was hard (above 15 in the RPE) the resistance was decreased. Patients had to perceive the exercise as somewhat hard according to subjective tolerance assessed by the RPE, so that the target intensity was 65% to 85% of individual's maximal capacity (231). The exercise duration was 10 minutes for the first sessions and increased up to 30 minutes within a few sessions. The last two weeks the cycling time increased up to 45 minutes in those who could achieve it. The cycle ergometer displays some information and gives feedback information for the patients that can motivate them, as revolutions per minute, power developed and distance virtually travelled (232). Further, it should be noted that this cycle ergometer also allows for passive motorized pedaling, but we always encouraged subjects to cycle actively.

Figure 3. 8 Cyclo ergometer in supine position

MONITORING

Each patient had a diary with his/her name in the clinical history. Every day that the subject performed the exercise the physical therapist wrote the data (for strength exercises: sets, repetitions, elastic band color, kilograms; and for the cycle ergometer: the resistance, the time and the distance).

HOME BASED PROGRAMME

The physical therapist asked the participants to attend an exercise session at their homes in order to: 1) give them all the necessary material to perform the program, 3) explain the exercises within the subject's daily environment, 3) encourage not only the participant to do the exercise but also the family to help them during the exercise session, and 4) motivate the patient and the family to perform the program in order to increase the adherence.

The participants were asked to perform the program at least three times per week, they could choose on dialysis days or on non-dialysis days, always trying to have a day off between each session, at any time of the day. The physical therapist supplied them with a weight to do the exercise program according to the 10 RM assessed in the dialysis service, a booklet containing the explanation for each exercise with pictures, and a diary to fulfill (APPENDIX 4. HOME – BASED PROTOCOL).

WARM-UP AND COOL-DOWN

The warm-up and the cool-down phases consisted of three minutes of walking, and five minutes of stretching (triceps sural, hamstrings, adductors, quadriceps). Every stretching exercise lasted 20 seconds and was performed three times per limb alternating both limbs.

MAIN PART

The main part of the program consisted of lower limb strengthening exercises. If the exercise required lifting weights, it was set at the 10 RM that was calculated at the beginning of the program and adapted every two weeks in the dialysis unit.

The intensity for all the exercise was adjusted by the degree difficulty according to the Borg Scale Rate of Perceived Exertion (RPE) (APPENDIX 5. THE BORG RATING OF PERCEIVED EXERTION SCALE) at level between 12 and 15. Subjects did not feel the exercise "somewhat light" (not less than 11 at the RPE) or "hard" (no more than 15 at the RPE).

The strength prescription started with 1 set per 10 repetitions and progressed to 3 sets per 8 to 10 repetitions, without pause between repetitions. In between of each strengthening exercise, participants had to walk during one minute as fast as they could without running or jogging. Total time of the program was around 45 minutes per session.

The first exercise consisted of extending one knee from a standardized position 90º flexed knee until 0º keeping limb horizontal, with attached weights applied to the ankle. The rhythm for this exercise was two seconds of concentric contraction, two seconds of isometric contraction and four seconds of eccentric contraction, without pauses between each repetition (118). Participant performed 1 set of 10 repetitions per each leg.

The second exercise consisted of a squat with support on the wall or a table (preferably on the wall). The timing was four seconds to bend the knees, two seconds of keep the squat position and two seconds to come back to the starting position If the subject was able to do this exercise without support on the wall, he or she was asked to put his/her hands in the waist.

The third exercise consisted of crossing the arms across the chest and to stand up and sit down from a chair. If subjects needed support to perform this exercise, they were allowed to push from both armrests, then push only from one armrest until they could stand up without any help. To increase the difficulty of the exercise, subjects were allowed to load extra weight under the physical therapist's supervision.

The fourth exercise consisted of knee flexion. Participant stood up with arms supported on the wall or on a table (preferably a wall) with attached weights applied to the ankle. They were asked to bend the knee bringing the heel back. The timing was two seconds of concentric contraction (knee flexion), two seconds of isometric contraction and four seconds of eccentric contraction (knee extension).

The fifth exercise consisted of hip extension keeping the knee extended, starting from the same position as the previous exercise. The timing was two seconds of concentric contraction (hip extension), two seconds of isometric contraction and four seconds of eccentric contraction (hip flexion).

The sixth exercise consisted of hip abduction with knee extended and with attached weights applied to the ankle. The individual touched the wall or a table (preferably the wall) to keep balance, and the body should be kept straight, without bending laterally. The timing was two seconds of abduction, two seconds of maintain contraction and four seconds of adduction.

The seventh exercise consisted of bilateral plantar flexion. The person touched the wall or a table (preferably the wall) to keep balance and have extra support, and the exercise consisted of raising the heels without bending the knees. The timing was to rise in one second, keep the position for three seconds and come back to the starting position in two seconds. If participants felt the exercise as too light, progression could be achieved by rising the whole body weight only with one heel, rising with one heel and get support only from one hand, or raise one heel without support.

Balance exercise consisted of maintaining the side-by-side position, and increasing progressively the difficulty by maintaining the semi-tandem and the tandem positions. Those participants that were not able to maintain the position could touch the wall with one hand. The balance position should be kept for 10 seconds. To increase difficulty, patients could keep the position without support and closing their eyes. Additionally, they were asked to keep one leg standing position for 10 seconds, or as long as they could. Subjects performed 1 set of 3 repetitions per each leg.

Participants were asked to walk at least 3 times per week between 15 - 30 minutes at normal speed and to end up with stretching exercises for the posterior muscles of the lower limbs.

MONITORING

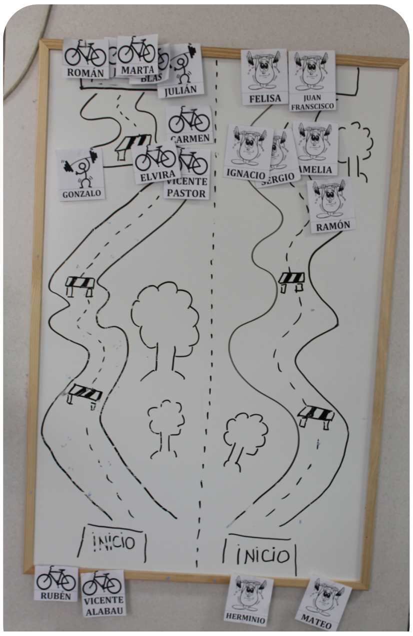
The sessions were discussed with a physical therapist during the first month and weekly until the end of the 16 weeks in the hemodialysis sessions. This person solved questions that participants could have, asked them if they were doing the exercise and motivated them to continue doing the exercise. Even that, participants were asked to complete a diary writing how long they were training, the weight they lifted to perform the exercise, the time they were walking and the heart rate plus blood pressure at the beginning and at the end of the training session.

ADHERENCE TO EXERCISE PROGRAM

Adherence to exercise was defined as the total number of session performed divided by the total number of sessions offered, multiplied per 100. Subjects were included in the analysis if they performed, at least, 50% of the sessions offered.

As a strategy to increase feedback and adherence, we located a whiteboard at the hemodialysis unit that could be seen by all participants. It contained the name of each person and two ways were drawn (one way for the intradialytic group, and another one for the Home based group), so that those subjects that performed the exercise sessions were more advanced than those that did not adhere to the treatment (Figure 3.9).

Figure 3. 9 Whiteboard on the hemodialysis unit with the name of each participant and represent both groups the intradialytic and home based



Another strategy to increase adherence was to deliver a medal by the end of the intervention to participants who followed the program.

Figure 3. 10 Some patients at the end of the program with their medals

CHAPTER 4. TEST – RETEST RELIABILITY AND MINIMAL DETECTABLE CHANGE SCORES FOR THE SHORT PHYSICAL PERFORMANCE BATTERY, ONE LEG STANDING TEST AND TIMED UP AND GO IN PEOPLE UNDERGOING HEMODIALYSIS

BACKGROUND: Functional tests are commonly used in chronic kidney disease patients undergoing hemodialysis. However, it is necessarily to determine the relative and absolute reliability of outcomes physical performance tests.

OBJECTIVE: The aims of this study were to assess the relative and the absolute reliability of the Short Physical Performance Battery (SPPB), one leg stance test (OSL) and Timed Up and Go test (TUG); and to calculate the minimally detectable change (MDC) scores for these tests in CKD patients receiving hemodialysis (HD)

METHODS: Seventy-one ESRD patients receiving HD therapy participated. Participants completed two testing sessions performed by the same examiner, 1 to 2 weeks apart, of the following tests: SPPB (n= 65), OLST (n= 62) and TUG (n=66).

OUTCOMES: The intraclass correlation coefficients computed for the SPPB were 0.94 (CI 95% 0.91 to 0.97), OLST = 0.90 (CI 95% 0.83 to 0.94) and TUG = 0.96 (CI 95% 0.94 to 0.98). The minimal detectable change (MDC) was calculated to be 1.7 points for the overall SPPB (CI 95% 1.3 to 2.1); 11.3 seconds to the OLST (CI 95% 8.9 to 14.2) and 2.9 seconds for the TUG test (CI 95% 2.2 to 3.7).

CONCLUSIONS: The SPPB, the OLST and the TUG tests were considered to offer acceptable reliability in this patient sample. The MDC data generated by these tests can be used to monitor “meaningful” change in activity of daily living-related functional capacity of these patients.

INTRODUCTION

Renal failure is a common problem these days. In fact, more than two million people in the world are treated by dialysis because a Chronic Kidney Disease (CKD) (233). According to the results of EPIRCE (Epidemiology in Chronic Renal Failure in Spain), 10% of adult population suffer any stage of renal failure and 6.8% present any stage between 3-5. In 2010 it was established that 4 million people suffered from CKD in Spain and needed renal replacement treatment (6). The most common renal replacement treatment is hemodialysis (HD), but other possible treatments are peritoneal dialysis or kidney transplantation. It has been shown that patients in HD have high comorbidity (above all cardiovascular problems) and physical function problems (149).

Since the early 80's, exercise programs have been undertaken as part of the treatment for patients with CKD and the benefits are described in the literature. Physical function tests are commonly used to assess the effectiveness and determine the effects of the intervention. These tests should be tested regarding reliability specifically in CKD population. A previous study studied the relative and absolute reliability and the Minimal Detectable Change (MDC) of several physical functional test, such as the Sit to Stand 10 and 60, one heel rise test, handgrip and 6 minutes walking test (118), but there are no studies regarding reliability of other commonly used tests.

Different authors have reported the functional properties for the Short Physical Performance Battery (SPPB), One Leg Standing Test (OLST) and Timed Up and Go (TUG) for several samples of predominantly elderly population.

The SPPB is a simple test that measures lower extremity function using tasks that mimic daily activities. It has been found to be useful to predict outcomes such as falls, institutionalization and death in elderly (195). This test had been used in CKD patient (152, 198) but the relative and absolute reliability has not been calculated before, either the MDC.

The OLST is also known in different studies as one-leg stance, one-leg balance, one-legged stance or unipedal balance. It measures the time in seconds that a person can stand on one leg. The OLST has been shown to be a good predictor of falls (234). As far as we know, there are no previous studies that use this test in CKD population.

The Timed Up and Go (TUG) is a simple and valid method to assess level of functional mobility (201). It requires the individual to stand up from a chair, walk three meters, turn, walk back and sit down. It measures the time taken to complete the test. This has been used in different chronic disease such as Alzheimer, chronic heart failure or chronic obstructive pulmonary disease (110, 206, 235); one of them is in CKD undergoing HD (170, 190 – 192) but the relative and absolute reliability and MDC has not been calculated before.

Aims and Hypothesis

The aim of this study was to calculate the test-retest reliability of several physical performance tests used in people undergoing hemodialysis (Short Physical Performance Battery, one leg stand balance and Timed Up and Go) and to calculate absolute reliability with the standard error of measurement (SEM) and minimal detectable change (MDC) scores at 90% confidence intervals (MDC_{90})

METHODS

Design

This study was a prospective, non-experimental, descriptive research design.

Participants

The participants were recruited from two hemodialysis units in Valencia and one unit from Terrassa, Barcelona (Spain) from 2013 to 2015.

All participants were informed of the protocol and procedures to be used, and written informed consent was obtained from each one, as approved by the Ethics Committee from *Hospital Universitario Doctor Peset.* This study was registered in Clinical Trials with the number NCT02830490.

Inclusion and exclusion criteria

The nephrologist, who gave authorization before solicitation of interest, evaluated inclusion criteria. Patients were included in the present study if they were at least 3 months in hemodialysis and the absence of acute or chronic medical conditions that would preclude the collection of outcome measure data.

Exclusion criteria were recent myocardial infarction (within 6 weeks), unstable angina, malignant arrhythmias and any disorder that was exacerbated by activity.

Demographic, anthropometric, and laboratory data

Demographic and clinical data were collected from the medical history and included age, sex, body mass index, time on hemodialysis, creatinine, albumin and hemoglobin levels, cause of kidney disease, and the Charlson comorbidity scale.

Procedure

Participants performed each test twice, with one to two weeks interval between the testing sessions, always on the dialysis day, immediately before the first hemodialysis session of the week. Every effort was made to keep all factors associated with testing sessions consistent: day of the week, time of day, the area in which the test was performed and the same person to assess. Participants performed the short physical performance battery, the one leg standing balance, and timed up and go test.

Researcher training

Two physical therapists assessed the tests (the SPPB, the OLST and the TUG). Researcher 1 and 2 had 11 and 8 years' experience on physical function evaluation, respectively.

Physical performance measures

Participants completed the SPPB, the OLST and the TUG in the same place and more or less at the same hour, although not all the subjects could be assessed in the test-retest.

For more detailed information about the physical performance test see CHAPTER 2. GENERAL METHODS.

Short Physical Performance Battery (SPPB)

The Short Physical Performance Battery (SPPB) is a test that measures lower extremity function, which includes objective performance-based measure of balance (side-by-side, semi-tandem and tandem), endurance (4 meters gait speed) and strength (five chair stands). Each component was scored from 0 to 4 and when summed yielded SPPB scores between 0 (poor) and 12 (best) performance (Table 4.1) (195). These tests were performed immediately before the first hemodialysis session of the week.

For testing the standing balance, the participants were asked to attempt to maintain their feet in the side-by-side, semi tandem (heel of one foot beside the big toe of the other foot), and tandem (heel of one foot directly in front of the other foot) positions for 10 seconds each.

For testing endurance, we asked the patients to walk at the normal pace, as if going to the store. Participants were allowed to use their usual walking aid although they were encouraged not to use it. Participants scored according to quartiles for the length of time required.

In order to test lower limbs strength subjects were asked to fold their arms across their chests and to stand up and sit down five times (STS-5) as quickly as possible. The test was performed with a chair that had no armrests and was backed up against a wall to minimize the risk falling. Stopwatch recorded the time taken since the researcher's instructions begin until the peak of the fifth rise (197, 236).

The SPPB has been found to be a reliable tool in dwelling older adult (ICC=0.82) (102), and in older women (ICC=0.88-0.92) (103). In addition, researchers have determined its minimal detectable change in older adults. The Standard Error of the Mean (SEM) was 1.42 points (104) and Guralnik et al (195) concluded that a 1 point change in SPPB score led meaningful differences in the risk for future mortality and incident disability.

Table 4. 1 Short Physical Performance Battery Scoring

Test		Scoring	Total
Balance Test	**Side by side**: the subject is asked to stand with both feet side by side and the time is measured	0 → Unable or 0 – 9 s 1 → 10 s	4 points
	Semi-Tandem: The subject is asked to stand with one foot slightly more in front of the other and the time is measured	0 → Unable or 0 – 9 s 1 → 10 s	
	Tandem: The subject is asked to stand with one food in front of the other and the time is measured	0 → Unable or 0 – 2 s 1 → 3 – 9 s 2 → 10 s	
4 m gait speed	The time taken for the subject to walk 4 m at the normal pace. It is measure twice. The best mark of the two trials is used. Use of aid in the test was recorded	1 → ≥ 8.70 s 2 → 6.21 – 8.70 s 3 → 4.82 – 6.20 s 4 → ≤ 4.82	4 points
5 STS	The time taken for the subject to rise from sitting in a chair 5 times as fast as possible is measured. The test is completed with arms cross in the chest and they were not allow to use tools to stand	0 → ≥ 60 s 1 → ≥ 16.70 2 → 13.70 – 16.69 s 3 → 11.20 – 13.69 s 4 → ≤ 11.19 s	4 points

s: seconds; **STS**: Sit to Stand

One leg Standing Test (OLST)

To perform the one leg standing test patients were allowed to choose their preferred leg. Participants' eyes were open, and their arms were allowed to move freely. All subjects wore shoes.

If they were having pain or other symptoms in the first leg, they were permitted to use the other leg. They had to maintain one leg stance for as long as possible.

The participants were given three trials to achieve 45 seconds. During each trial the subjects were verbally encouraged to maintain one leg stand position for as long as possible. The longest balance time of the recorded trials was used for the data analysis.

The test concluded if the participant used their arms to touch the wall, if the lift foot touched the ground, if the subject moved the foot that is standing or when time arrived to 45 seconds (199).

OLST has been shown to be a good predictor of falls (234). The ICC when the maximum standing time is 30 seconds with eyes open in elderly ranges from 0.60 (105) to 0.86 (108), and the MDC_{95} is 24.1 seconds (108); for people with hip fracture in the affected leg the ICC is 0.75 and the MDC_{95} is 10.7 seconds, while in the non-affected leg the ICC is 0.83 and the MDC_{95} is 5.5 seconds (107); and in patients with lower limb amputation the ICC is 0.87 using a maximum time of 60 seconds to do the test with eyes open and the MDC_{95} is 2.74 seconds (109).

Timed Up and Go (TUG)

For the Timed Up and Go test (TUG) subjects were given verbal instructions to stand up from a standard arm chair with use the arms if needed, walk three meters as quickly and safely as possible, turn back the cone, walk back and sit down to the chair. Participants were allowed to wear their regular footwear, and use walking aid if needed. A stopwatch was started on the “go” and stopped when fully sitting position that back against the backrest was reached again. Time to complete the test from three consecutive trials, the first one to be familiar with the test, was registered. The best mark of the three trials was analyzed (202 – 204). The TUG has shown excellent test-retest reliability in older adults, with an ICC over 0.98 (201, 204), in patients with chronic heart failure (ICC=0.93) (110) patients with Parkinson disease (ICC= 0.80) (111) or Alzheimer Disease (ICC= 0.985-0.988; MDC_{90} = 4.09 seconds) (112).

Statistics

Descriptive data are reported as mean (standard deviation), if normally distributed, or as median (range). To assess whether the data were normally distributed we used the Kolmogorov-Smirnov test. Paired comparisons to assess for systematic bias between trial weeks were performed with the paired t test or the Wilcoxon signed rank test. The intraclass correlation coefficient (ICC) (model alpha) was used for the assessment of the test-retest reliability of data for all repeated test, 2-way random-effects model, which is appropriate for this study. An ICC above 0.75 was considered to demonstrate good reliability, although for clinical measures it has been suggested that the ICC should exceed 0.90 (237). The SEM was used to determine absolute reliability and represents the extent to which variable can vary in the measurement process. It was calculated with the following formula:

SEM = SD x $\sqrt{(1-r)}$

Where the SD is the standard deviation and r is the ICC for the participant groups.

The MDC_{90} was computed from the SEM and was calculated in terms of confidence of prediction with the following formula:

MDC_{90} = SEM x 1.65 x $\sqrt{2}$

The MDC is defined as the amount of change in a measurement necessary to conclude that the difference is not attributable to error, it is the smallest change that falls outside the expected range of error. Any change exceeding the MDC_{90} is considered true change (112, 118, 264, 265).

The level of significance was predetermined to be P ≤ 0.05 for all statistical analysis. Data management and analysis was carried out using the Statistical Package for Social Sciences (SPSS) version 20.0 for Windows.

RESULTS

Data were collected from 71 participants in ESRD receiving hemodialysis treatment (29 women and 42 men) from three different units. The mean age was 61.7 ± 16.4 years old. Descriptive statistics for the 71 participants are shown in Table 4.2. The flow chart (Figure 4.1) shows the number of participants who performed each test. No adverse events occurred during testing. The results of repeated test are shown in Table 4.3. The ICCs for test-retest reliability were high for all of the outcome measures. The ICC for the SPPB was 0.94 (95% confidence interval = 0.91-0.97); for the OLST was 0.90 (95% confidence interval = 0.83-0.94) and for TUG the ICC was 0.96 (95% confidence interval = 0.94-0.98). According to the paired comparisons, there were non-significant differences between trial 1 and trial 2 in any test. Table 4 also presents the MDC_{90} values for the SPPB, the OLST and the TUG (1.7 points; 11.3 seconds and 2.9 seconds respectively).

Figure 4. 1 Flow Chart for Study Participants in the test - retest reliability and minimal detectable change for the SPPB (Short Physical Performance Battery, the OLST (One Leg Standing Test) and TUG (Timed Up and Go)

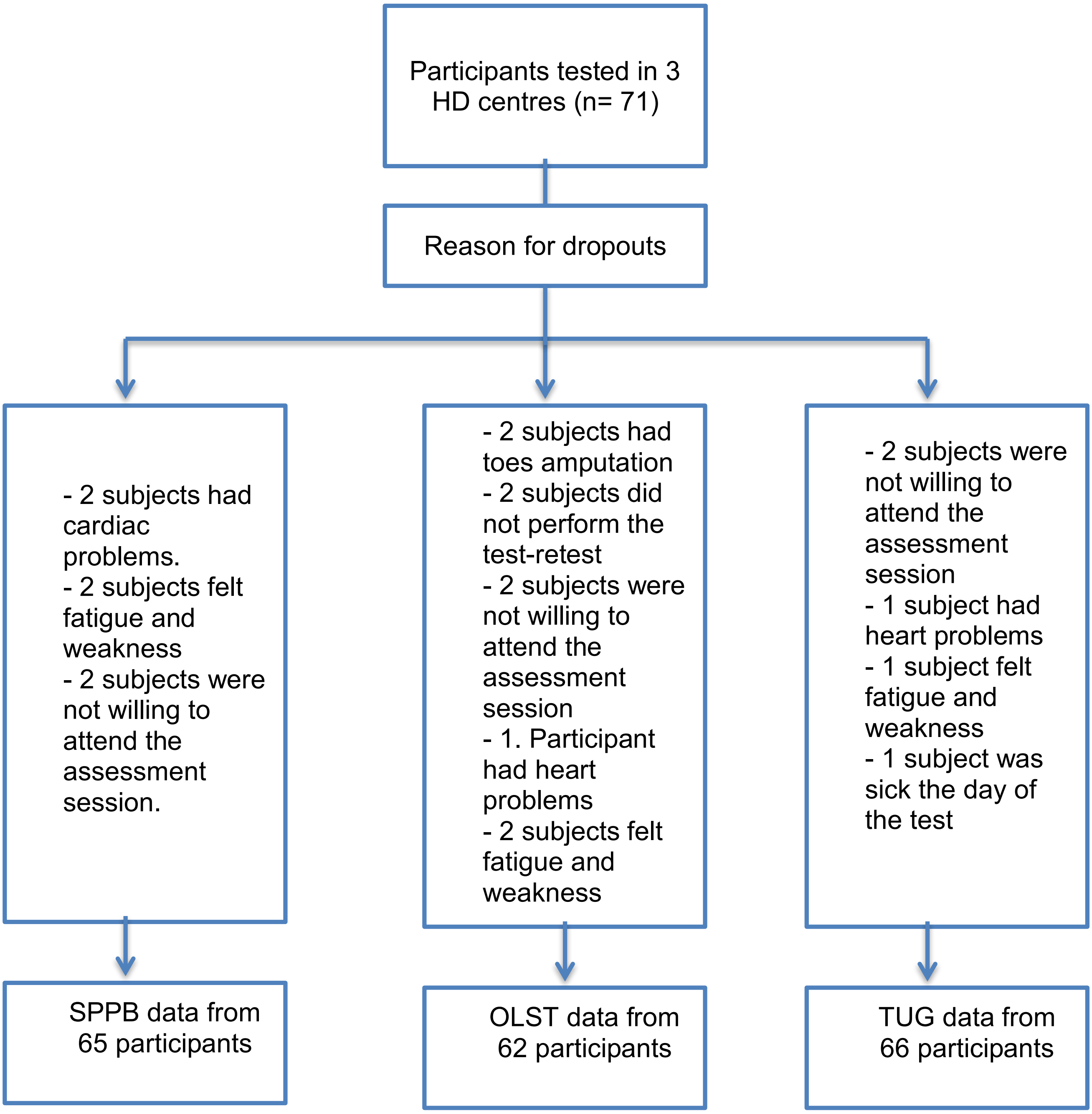


Table 4. 2 Demographic and Clinical Data for Study Participants in the test - retest reliability and minismal detectable change study (N=66)

Characteristic	Value
Age (mean ± SD)	61.7 ± 16.4
Sex (women:men)	29:42
Body Mass Index (kg/m2) (mean ± SD)	25.87 ± 6.23
Time on hemodialysis (median in month P25-P75)	56 months 34-96 months
Creatinine levels (mg/dL) (mean ± SD)	9.23 ± 3.04
Hemoglobin levels (g/dL) (mean ± SD)	11.00 ± 1.37
Albumin levels (g/dL) (mean ± SD)	4.18 ± 4.52
Cause of Kidney Disease (nº of participants)	
• **Diabetes Mellitus**	14
• **Glomerulonephritis**	13
• **Nephroangiosclerosis**	6
• **Lupus**	3
• **Pyelonephritis**	5
• **Polycystic**	3
• **High Blood Pressure**	4
• **Others**	23
Charlson cormorbidity (mean ± SD)	6.73 ± 2.43

Table 4. 3 Reliability Results for Physical Performance test in people undergoing hemodialysis

Test	No of participants	Trial 1	Trial 2	ICC for Trial 1 vs Trial 2	95% CI for ICC	P for significance of difference between Trial 1 and Trial 2
		Median (Min-Max)	Median (Min-Max)			
SPPB (points)	65	11 (0-12)	11(0-12)	0.94	0.91-0.97	0.942
OLST (seconds)	62	4.42 (0-45)	8.05 (0-45)	0.90	0.83-0.94	0.895
TUG (seconds)	66	9.03 (4.60- 37.5)	8.64 (3.72-32.47)	0.96	0.94-0.98	0.962

OLST: One Leg Standing Test; **SPPB:** Short Physical Performance Test; **TUG:** TUG: Timed Up and Go

Table 4. 4 Minimal Detectable Change Scores at 90% Confidence Intervals (MDC90) for Various Tests

Test	MDC_{90}	CI 95%	SEM	CI 95%
SPPB (points)	1.7	1.3 - 2.1	0.72	0.56-0.91
OLST (seconds)	11.3	8.9 – 14.2	4.82	3.80-6.10
TUG (seconds)	2.9	2.2 – 3.7	1.24	0.96-3.66

CI: Confidence Interval; **OLST**: One Leg Standing Test measures in seconds; **SPPB**: Short Physical Performance Battery measures in points; **TUG**: Timed Up and Go measures in seconds

DISCUSSION

Relative reliability measured by the ICC represents the degree of reproducibility between 2 successive assessments. Our findings demonstrated that the test-retest reliability of the clinical tests was excellent, since all values were equal or above 0.90 (237). The SPPB, the OLST and the TUG are widely used performance tests probably due to their simplicity and low cost.

Test-retest reliability

The SPPB examines three areas of lower extremity (static balance, gait speed and getting in and out of a chair) that represent essential tasks for independent living and are important outcome measure in CKD patients. It has been found to be useful to predict outcomes such as falls, institutionalization and death in elderly population (195). This test has been used in HD patients (152, 263). To our knowledge, this is the first study that calculates the relative reliability of the SPPB in hemodialysis patients. According to our results, this test has an excellent test-retest reliability (ICC = 0.94; 95% CI = 0.91 – 0.97). This results are consistent with values reported in other populations. In a dwelling older population (n = 487 with mean age 74.1 ± 5.7 years old), the ICC is 0.82 (102), and for older women (n= 1002 with an average age of 78.3 ± 0.3 years old) the ICC is 0.88 – 0.92 (103). Studenski et al (102) performed the test within 1 week, as in this study, but the place where the SPPB was measure was different: the first week they assessed the SPPB during outpatient clinic visit and the second one during in a comprehensive home visit. In our study, all the measures were in the same place within 1 to 2 weeks. Given that our ICC is high, we could consider the SPPB as a good physical performance measure to use in CKD patients on hemodialysis to identify loss of mobility. Future longitudinal studies should clarify if we could predict difficulties in activities of daily living as previous studies have reported in elderly and in older hospitalized patients (103, 196).

No previous studies on patients undergoing hemodialysis have reported relative reliability for the OLST. However, previous studies reported the ICCs of this test. In elderly populations the ICC has been shown to 0.60 (105) and

0.86 (108), hip fracture (107) ICC for affected leg = 0.75 and ICC for the non-affected leg = 0.83), and for patients with lower limb amputation (109) (ICC=0.87), lower values than the one obtained in our sample (ICC=0.90). By the other hand, in healthy military health care beneficiaries aged 18 and older, an ICC of 0.994 on a subgroup of 50 participants was reported.

There are many differences in the literature to perform this test and, surprisingly, there is non-consensus regarding execution. For example, some studies used as maximum time 10 seconds (238, 239), others 30 seconds (105 107, 240), 45 seconds (199, 238) or 60 seconds (108, 109, 241). The reason why we used 45 seconds as maximum time is because, Briggs et al 1989 (200) felt that a limit of 45 seconds would result in normal distribution of times (199, 200). Another factor that varies in the procedure is the number of trials to achieve the maximum time; while some studies do not report them, trials reported in the literature range between 3 (238, 241) and 5 (108, 109). Some authors use the average of the trials (108, 238) while others use the longest time of the trials for statistical analysis (109, 200, 241). Our sample had 3 trials to achieve the longest time possible and the best mark was used for data analysis. We followed Hurvitz et al. (199) procedure based on Briggs et al. (200), who suggested that three trials appear to provide a good indication of balance capabilities since they observed that the best trial results were found among the first three trials of the test. Other differences between studies are reported in the way to execute the OLST. In our study participants were allowed to have eyes open as in the studies from Kristensen et al. (109), Springer et al. (238), Giorgetti et al. (240) and Chomiack et al. (241); they were able to wear shoes on, to choose the leg they preferred for the test, and to move their arms to maintain balance (199). The number of participants, so as their age, could also influence results. We included more participants than previous studies (n=62) and the age ranged from 21 to 90 years old, mean age 61.4 ± 16.4, being a relatively young sample compared to others studies (see table 4.5). Future studies should report if this procedure is useful to predict falls in this cohort.

Table 4. 5 Characteristics in selected studies using the One Leg Standing test

Author (year)	Type of population	N	Range age min-max	Mean age (SD)
Wolinsky et al. (105)	Elderly African Americans	53	50 – 64	56.6
Sherrington & Lord (107)	Hip fracture	30	62 – 95	79.8 (10.0)
Goldberg et al. (108)	Older community dwelling	25	60 – 89	72.0 (9.1)
Kristensen et al. (109)	Lower limb amputation	36		67.4 (10.6)
Giorgetti et al. (240)	Non-disabled community	21	69 – 85	73.1
	Older people with some physical disability	21	61 – 89	75
Chomiack et al. (241)	Parkinson disease	27		67.1 (10.2)

The TUG, is a very common test to assess functional mobility. It has been described as valid, and relative reliability values are reported in different population, such as elderly (ICC=0.99) (201) (ICC = 0.98) (204), chronic heart failure (ICC=0.93) (110), Parkinson disease (ICC= 0.80) (111) and Alzheimer disease (ICC = 0.985-0.988) (112) Our results suggest that relative reliability of this test for patients undergoing hemodialysis is excellent (ICC=0.96), and therefore it seems that this is an appropriate test to report physical function of this cohort.

Our findings demonstrate that test-retest reliability (relative reliability) for all the clinical tests was excellent. Factors that could explain this good results and that would be recommended for clinical application of the tests are to perform the tests before the hemodialysis session the same day of the week, good researchers' training and standardization of the evaluator's instructions. However, it is surprising that a sample with high comorbidity (such as CKD maintenance hemodialysis) present better ICC compared with other cohorts that we assume have less variability in their health (such as elderly with no chronic disease). Moreover, we can think that young people receiving renal replacement treatment have better physical conditioning compared with elderly population receiving hemodialysis; consequently, they can be more constant in their physical condition. Another reason could be due to the protocol followed by the researchers, this was a intra rater reliability study that followed standardized instructions, at the same day of the week within 1 to 2 weeks apart. Researchers who performed the tests were trained to ensure standarization procedures (APPENDIX 2. INSTRUCTIONS – SCRIPTS –).

Surprisingly, in the review carried out in the present thesis about functional testing, we found inconsistencies between testing protocols and variety of tests across published studies, as we can observe in the OLST. These factors could lead to report inappropriate results and comparison between studies outcomes turns out to be difficult. The testing instructions (APPPENDIX 2. INSTRUCTIONS – SCRIPTS –) were the result of consensus achieved between the different research teams of every center where the study was undertaken. We believe it is very important that both researchers and clinicians assess physical functioning with the same tools using standardized instructions.

Minimal detectable change (MDC)

Although test-retest reliability in patients with chronic kidney disease undergoing hemodialysis was excellent, there was still a substantial degree of variability in performance for individual participants from one test session to the next. Table 4.4 shows high values of minimal detectable change.

The MDC_{90} is the magnitude of change that a measurement must demonstrate to exceed the anticipated measurement error and variability, and is a conservative estimate of a change in score that is clinically meaningful. The magnitude of clinically meaningful change in physical performance measures can help clinicians and researchers in CKD to determine changes between CKD patients undergoing HD (118).

The MDC from for the SPPB, the OLST and the TUG in CKD have been studied previously in other populations such as, elderly (104, 105, 108, 195), hip fracture (107) and lower amputation (109), or Alzheimer disease (112). Nevertheless, to our knowledge this is the first study to calculate the MDC of these tests in patients with CKD undergoing hemodialysis.

In the present study the SPPB reported a MDC_{90} of 1.7 points, whereas in elderly population a 1-point change led to meaningful differences in the risk for future mortality and incident disability (195). In another study with older adults, with a big and old-age sample (n= 482, mean age 74.1 ± 5.7 years old) a SEM of 1.42 points was reported (104), while we obtained a SEM of 0.72 points. The time frame was wider than in our study, since they evaluated subjects at the participant's house every three months for the first year and every 6 months for the second year. In our study all the measurement conditions were strictly replicated, but patients in maintenance hemodialysis present wide variation in the physiological and clinical status, which can provide heterogeneity in the results.

For the OLST we found a MDC_{90} of 11.3 seconds. In a community of dwelling people the MDC_{95} was 24.1 seconds (108), which could be explained by the high SD found in the study sample (20.4 seconds) (242). In patients with lower limb amputation the MDC_{95} was 2.74 seconds (109). The difference also could be related to the evaluation procedure. In the current study we performed 3 trials with a maximum time of 45 seconds, while other studies performed 5 trials with a maximum time of 60 seconds (108, 109). We chose 3 trials instead of 5 because in order to obtain better marks in the first trials, to have less variability, and to avoid fatigability in lower muscles to achieve the longest time possible (200).

The MDC_{90} for the TUG in chronic kidney disease undergoing HD was 2.9 seconds. In a cohort with Parkinson disease the MDC_{95} was 3.5 seconds (111) (similar to our results if we calculate MDC_{90}) and in another sample with Alzheimer Disease the MDC_{90} was 4.09 seconds (112). The high MDC found in Alzheimer Disease could be explained by the high SD reported (mild moderate Alzheimer disease TUG = 19.95 ± 9.81 seconds and moderately severe to severe Alzheimer disease TUG = 28.01 ± 17.49 seconds). Patients with higher level of dementia will have higher variability, and will need more time to perform the test compared to less affected subjects. The higher variability results in higher MDC. Another difference between studies was the number of trials performed. In Huang et al. (111) they only measured the TUG once to avoid fatigue, but they concluded that more trials would increase the stability of the measurement and would reduce the MDC. In patients with Alzheimer disease subjects performed 2 trials (112), while in our study they performed 3 trials. So, it seems that more than one trial increases the stability of the test, and as a result the MDC decreases.

In general, MDC_{90} of 1.7 points for the SPPB, MDC_{90} of 11.3 seconds in the OLST and MDC_{90} of 2.9 seconds in the TUG indicate that results of these three tests of 90% of subjects with CKD in hemodialysis will vary by less than 1.7 points in the SPPB, 11.3 seconds in the OLST and 2.9 seconds in the TUG. This implies that a change greater than these values are necessary in an individual patient in order to be 90% certain that the change is not due to inter trial variability.

In the clinical field, researchers and clinician should use the MDC values to determine whether a true change in the test has occurred in CKD patients in maintenance HD and to determine the amount of change that is associated with worse prognosis.

STUDY LIMITATIONS

The main limitation of this study was the variability that this cohort presents. The sample age range was high and participation was low. The time used to assess the patient before the hemodialysis session was very short because we had 30 minutes to measure them. Despite this time constrain, we followed a strict methodology. Another limitation that we can find is in the OLST testing procedure, because there is non-consensus in the literature.

CONCLUSIONS

In conclusion, the results of the present study demonstrated excellent test-retest reliability for the SPPB, the OLST and the TUG in people undergoing hemodialysis. The MDC_{90} values for each test provide clinicians with thresholds for identifying changes beyond those expected from individual variability. This information will help in monitoring performance changes over time and assessing the effectiveness interventions to improve physical performance in people receiving hemodialysis treatment.

CHAPTER 5. QUANTIFYING THE DETERIORATION OF PHYSICAL FUNCTION ALONG 6 MONTHS IN PATIENTS WITH CHRONIC KIDNEY DISEASE

BACKGROUND: Physical function in patients undergoing hemodialysis (HD) decreases over time but this decrease has not been quantified over time

OBJECTIVE: The aim of this study was to quantify the degree of functional deterioration experienced by chronic kidney disease patients undertaking hemodialysis during a six-month period.

METHODS: This was a longitudinal observational study. Subjects were evaluated at baseline and after 6 months, by the same examiner. The battery of functional tests included: The Short Physical Performance Battery (SPPB), the One Leg Standing Test (OLST), the Timed Up and Go (TUG), the Sit to Stand 10 and 60 (STS-10/60), Handgrip, the One leg heel rise, and the 6 minutes walking test (6MWT)

OUTCOMES: Fifty-one patients receiving HD participated. Only the TUG showed a significant change, only by 0.1 seconds (pre = 8.3 (0 – 55); post = 8.2 (0 – 28.3) seconds; p = 0.026 bilateral significance). No significant changes were observed after an observation period of 6 months on SPPB, OLST, STS 10, STS 60, One leg heel rise and 6MWT.

CONCLUSIONS: Since there are no significant changes over a 6 months' period on physical function of patients undergoing hemodialysis, the recommendation for the dialysis units would be to assess physical function yearly.

INTRODUCTION

Chronic Kidney Disease (CKD) is a common disease worldwide. In Spain, approximately 4 millions of people suffer from CKD. From those, 50.909 are in renal replacement therapy, being most of them in Hemodialysis (HD). The CKD prevalence is progressively increasing with aging. According to the Spanish register of renal patients 2012, 22% of the patients are 64 years old and 40% are older than 80 years old (4). The global survival rate for patients in dialysis treatment is 12.9% at ten years (4). Even that HD is an advanced technique that prolongs life, this cohort suffers from cardiovascular and musculoskeletal disorders that contribute to muscle wasting and physical function decline (38, 119). Subjects undergoing hemodialysis have low physical activity level, since they have imposed immobilization over 3-4 hours per 3-4 sessions per week (a total of 9-16 hours per week). Some of the symptoms that present CKD patients, predominantly in lower limbs, are muscle weakness, fatigue, myoclonus and cramps. These symptoms limit their work and their daily activities dramatically (35, 36). Over the years, this has been shown that contribute to sedentary behavior provoking more deterioration and worsening of health status finishing in disability, loss of independence and increased hospitalization and death risk (82, 119 121 – 124) but is unknown the rhythm at which physical function deterioration occurs.

Physical functioning is defined as individual’s ability to perform activities required in their daily lives (94). Assessment of physical function is valuable in clinical practice to: 1) Identify patients who may benefit from preventive interventions; 2) identify patients at high risk of early death who may be targeted for more extensive evaluation for potential modifiable risks to health and survival; 3) better characterize patients as likely to be in poor health and function; 4) monitor over time to identify a decline in function that may indicate a new health problem; 5) stratify risk for surgery, chemotherapy, or other complex clinical interventions and 6) monitor the effectiveness of clinical behavioral interventions (95).

There are several ways to evaluate the physical conditioning (laboratory measures, physical performance testing and self-reported measures). Limited exercise testing under laboratory conditions is not always well tolerated. As an alternative, different tests have been developed to measure physical performance in daily life.

The following tests have been used in people with renal failure and all of them have shown to be reliable (118, CHAPTER 4. TEST – RETEST RELIABILITY AND MINIMAL DETECTABLE CHANGE SCORES FOR THE SHORT PHYSICAL PERFORMANCE TEST, ONE LEG STANDING TEST AND TIMED UP AND GO IN PEOPLE UNDERGOING HEMODIALYSIS).

The Short Physical Performance Battery (SPPB) predicts disability, recurrent hospitalization, institutionalization and death in general population (195, 197). The One Leg Standing test (OLST) has been shown to be a good predictor of falls (234) although there is non-consensus regarding execution in the literature. The Timed Up and Go (TUG) indicates falls in the community dwelling people assessing level of functional mobility (201). The STS-10 (sit to stand to sit [STS] test has been recommended to quantify lower extremity weakness (118, 213), while the STS-60 has been used as a surrogate index of muscle endurance (114, 172). The One Leg Heel Rise test predicts weakness in calf muscles in early pre-dialysis contributing in the alteration gait pattern (118, 244). The maximal voluntary handgrip strength is necessary for optimal performance of activities of daily living. Greater handgrip strength increases the probability of survival of patients undergoing dialysis (118, 245). The six minutes walking test (6MWT) assesses the impact of renal rehabilitation (118).

Despite assessment of physical function is valuable in clinical practice, we do not know if 6 months is a time period long enough to show physical functioning decline.

Aims and Hypothesis

The purpose of this study was to quantify the physical functioning change experienced by chronic kidney disease patients undertaking hemodialysis during a six-month period. We hypothesized that physical functioning tests will show a significant decline over this time.

METHODS

Design

This study was a prospective, non-experimental, descriptive study

Participants

Participants were recruited from two hemodialysis units in Valencia and one unit from Terrassa, Barcelona (Spain) from 2013 to 2015.

All participants were informed of the protocol and procedures to be used, and written informed consent was obtained after approval by the Ethics Committee from *Hospital Universitario Doctor Peset*. This study was registered in Clinical trials with the number NCT02832466.

Inclusion and exclusion criteria

The nephrologist gave authorization before solicitation of interest according to the inclusion criteria. Patients with stage KDIGO 5 were included in the present study if they were at least 3 months in hemodialysis and the absence of acute or chronic medical conditions that would preclude the collection of outcome measure data.

Exclusion criteria were recent myocardial infarction (within 6 weeks), unstable angina, malignant arrhythmias, lower limb amputation without prosthesis, cerebral vascular disease (ictus, transit ischemia…), musculoskeletal or respiratory alteration that can worsen with tests and impossibility to achieve the tests.

Assessments

Demographic and clinical data were collected from the medical history and included age, sex, body mass index, time on hemodialysis, hemoglobin level, albumin level, creatinine level, cause of kidney disease, and the Charlson comorbidity scale. Physical performance tests were tested at baseline and by the end of the observation period, after 6 months.

For more detailed information about the physical performance test see CHAPTER 2. GENERAL METHODS.

Short Physical Performance Battery (SPPB)

The Short Physical Performance Test was performed immediately before the first hemodialysis day of the week.

The SPPB is a battery of tests that involves: balance test (side-by-side, semi-tandem, and tandem position), gait speed 4 meters and strength (five-chair stand). It is a standardized test and is very easy to administer. The score ranges from 0 to 12 points, higher scores meaning better physical function (see table 5.1). This test has been widely use as predictor of disability, recurrent hospitalization and death in general population (195, 197). The Standard Error of the Mean (SEM) was calculates by Perera et al. (104) 1.42 points in older adults and Guralnik et al. (195) concluded that a 1 point change in SPPB score led meaningful differences in the risk for future mortality and incident disability. The ICC for this procedure in CKD is 0.94 and the MDC_{90}= 1.7 points) (CHAPTER 4. TEST – RETEST RELIABILITY AND MINIMAL DETECTABLE CHANGE SCORES FOR THE SHORT PHYSICAL PERFORMANCE TEST, ONE LEG STANDING TEST AND TIMED UP AND GO IN PEOPLE UNDERGOING HEMODIALYSIS).

Table 5. 1 Classification of limitations based on Short Physical Performance Battery Score. Classification by Guralnik et al. (197)

Score	Classification
0-3	Severe limitation
4-6	Moderate limitations
7-9	Mild limitations
10-12	Minimal limitations

One leg Standing Test (OLST)

The One Leg Standing Test (OLST) tests was performed immediately before the first hemodialysis day of the week.

To perform OLST the patients were allowed to choose the leg they preferred to complete the test. Eyes were open, and the arms were allowed to move freely. All subjects wore shoes. If they experienced pain or other symptoms in the first leg, they were allowed to use the other leg. They had to maintain one leg stance for as long as possible. The participants were given three trials to achieve 45 seconds and the best mark of those three was used for the analysis (199). During each trial the subjects were verbally encouraged to maintain one leg stand position for as long as possible and they were able to rest if needed. The test concluded when the participant used their arms to touch the wall, if the foot touched the ground, if the subject moved the foot which is standing or when time arrived to 45 seconds (199). It has been shown to be a good predictor of falls (234). In patients with hip fracture, the ICC in the affected leg is 0.75 and the MDC_{95} is 10.7 seconds, while in the non-affected leg the ICC is 0.83 and the MDC_{95} is 5.5 seconds using a maximum time of 30 seconds to do the test. The ICC for this procedure in CKD is 0.90 and the MDC_{90}= 11.3 seconds) (CHAPTER 4. TEST – RETEST RELIABILITY AND MINIMAL DETECTABLE CHANGE SCORES FOR THE SHORT PHYSICAL PERFORMANCE TEST, ONE LEG STANDING TEST AND TIMED UP AND GO IN PEOPLE UNDERGOING HEMODIALYSIS).

Timed Up and Go (TUG)

The Timed Up and Go (TUG) tests was performed immediately before the first hemodialysis day of the week.

The TUG measures the time it takes a subject to stand up from a standard armchair, walk a distance of three meters as quickly and safely as possible, turn back the cone, walk back and sit down to the chair. Participants were permitted to use the arms if needed to stand up from the chair and they were allowed to wear their regular footwear, and use walking aid if needed. The time taken to complete the test was measured in seconds. The first opportunity was to become familiar with the test. The best of the three trials was used for analysis (201). The TUG has shown excellent test-retest reliability in older adults, with an ICC over 0.98 (201). The ICC for this procedure in CKD is 0.96 and a MDC_{90} = 2.9 seconds (CHAPTER 4. TEST – RETEST RELIABILITY AND MINIMAL DETECTABLE CHANGE SCORES FOR THE SHORT PHYSICAL PERFORMANCE TEST, ONE LEG STANDING TEST AND TIMED UP AND GO IN PEOPLE UNDERGOING HEMODIALYSIS)

Sit to Stand 10 and Sit to Stand 60 (STS-10/STS-60)

Both tests were performed immediately before the second hemodialysis day of the week.

First, participants performed the Sit to Stand – 10 (STS-10) and after a rest period to allow heart rate and blood pressure to decrease at baseline levels, they performed the Sit to Stand – 60 (STS-60).

The STS-10 consists of measuring the time in (in seconds) required to perform 10 consecutive repetitions of getting up and sitting down from a standard chair. The test starts and finishes at the sitting position. Participants had crossed arms on the chest and sitting with their back against the chair. Subjects were instructed to perform the task “as fast as possible”. Participants were allowed a practice trial before the test.

The STS-60 consists of measuring the number of repetitions of getting up and sitting down from a chair, with arms folded across on their chest, achieved in sixty seconds. Each repetition started and finished at the sitting position, and if a participant was standing when the time was over, it was considered half a repetition. Participants were allowed to stop if rest was needed and to continue performing the task until the 60 seconds were over.

Participants after each test described the degree of difficulty, determined as the rate of perceived exertion (RPE), measured with the Borg Scale from 6 to 20. These tests are reliable in this population (ICC=0.88 for the STS-10 and ICC= 0.97 for the STS-60) and their minimal detectable change is 8.4 seconds for the STS-10 while for the STS-60 are 4.0 repetitions (118).

One leg heel rise Test

This test was also performed immediately before the second hemodialysis session of the week. To perform this test subjects wore only socks (no foot-wear). We used a metronome to keep the rhythm, one lift every second and one second to return to the starting position.

Participants were allowed to have one trial to become familiar with testing procedure and were instructed to lift the heel as high as possible at the metronome rhythm until no further heel rises could be performed due to exhaustion. The test finished if the participant leaned or pushed against the wall or their knees were flexed, according to the examiner's observation. Also they were instructed to perform a maximum of 25 repetitions since it is considered the average number of repetitions performed by people who are healthy (214, 215). They performed the test with each leg and we recorded the degree of difficulty determined by RPE. This test has shown to be reliable for chronic kidney disease (ICC for the right leg was 0.97 while for the left leg was 0.94) and the minimal detectable change was 3.7 repetitions for the right leg and 5.2 repetitions for the left leg (118).

Handgrip Strength dynamometer

In addition, before the second hemodialysis session, we performed the handgrip strength test with a handgrip dynamometer (JAMAR Sammons Preston Rolyan, Chicago, Illinois, USA) to measure the amount of strength developed by each hand. Participants were positioned sitting in a chair with feet touching the floor with knees flexed in 90º, shoulder in neutral rotation, elbow flexed in 90º lean on the table, wrist and forearm semi pronated (0-30º) and wrist ulnar deviation between 0-15º, and proximal inter phalangeal articulations in 90º (211, 212, 246, 247).

We started always with dominant hand, and participants performed three repetitions per each hand. We respected an interval of 15 seconds between repetition and repetition to muscle. The instructions were to press progressively until maximum strength and keep it for 3 seconds.

This test has demonstrated high test-retest reliability in CKD patients (dominant hand ICC = 0.96 and non-dominant hand ICC = 0.95). The minimal detectable change for patients with end stage disease was 3.4 kg for both, dominant and non-dominant hand (118).

Six Minutes Walking Test (6MWT)

Immediately before the third hemodialysis session the six minutes walking test was performed, because by the end of the week the extra fluid retained by the participants was at its lowest level, minimizing its influence on the test results. The 6MWT was performed in a 20 - 30 meters corridor located in the hemodialysis unit, depending on the dialysis center. Tape was placed every two meters.

Participants were asked to walk the longest distance possible in 6 minutes by walking continuously the 20 or 30 meters indicated on the floor, turning around at the final mark without stopping. The standardized order given to the participants was “walk as far as possible for 6 minutes, but do not run or jog” (216). They were allowed to use any aids used in their daily life. They could turn down their speed or stop if needed and restart later. Heart rate and blood pressure were measured before and immediately after the test (202, 217, 248). We recorded the distance covered and the degree of difficulty determined by the RPE at the end of the test. This is a reliable test for chronic kidney disease patients (ICC 0.94) and the minimal detectable change is 66.3 meters (118).

Statistics

Outcomes are reported as mean (standard deviation), data are normally distributed as mean (standard deviation) plus median (minimum-maximum) if there are not normally distributed. The Kolmogorov Smirnov test was used to check data distribution. To analyze change over time, we used the non-parametric test Wilcoxon paired sample statistics to compare the measures at the beginning and at the end of the study when the sample was not normally distributed, and the paired samples t – test when data were normally distributed. Level of significance was set at $P \leq 0.05$ for all statistical analyses. The SPSS package version 20.0 for Windows was used for data management and analysis.

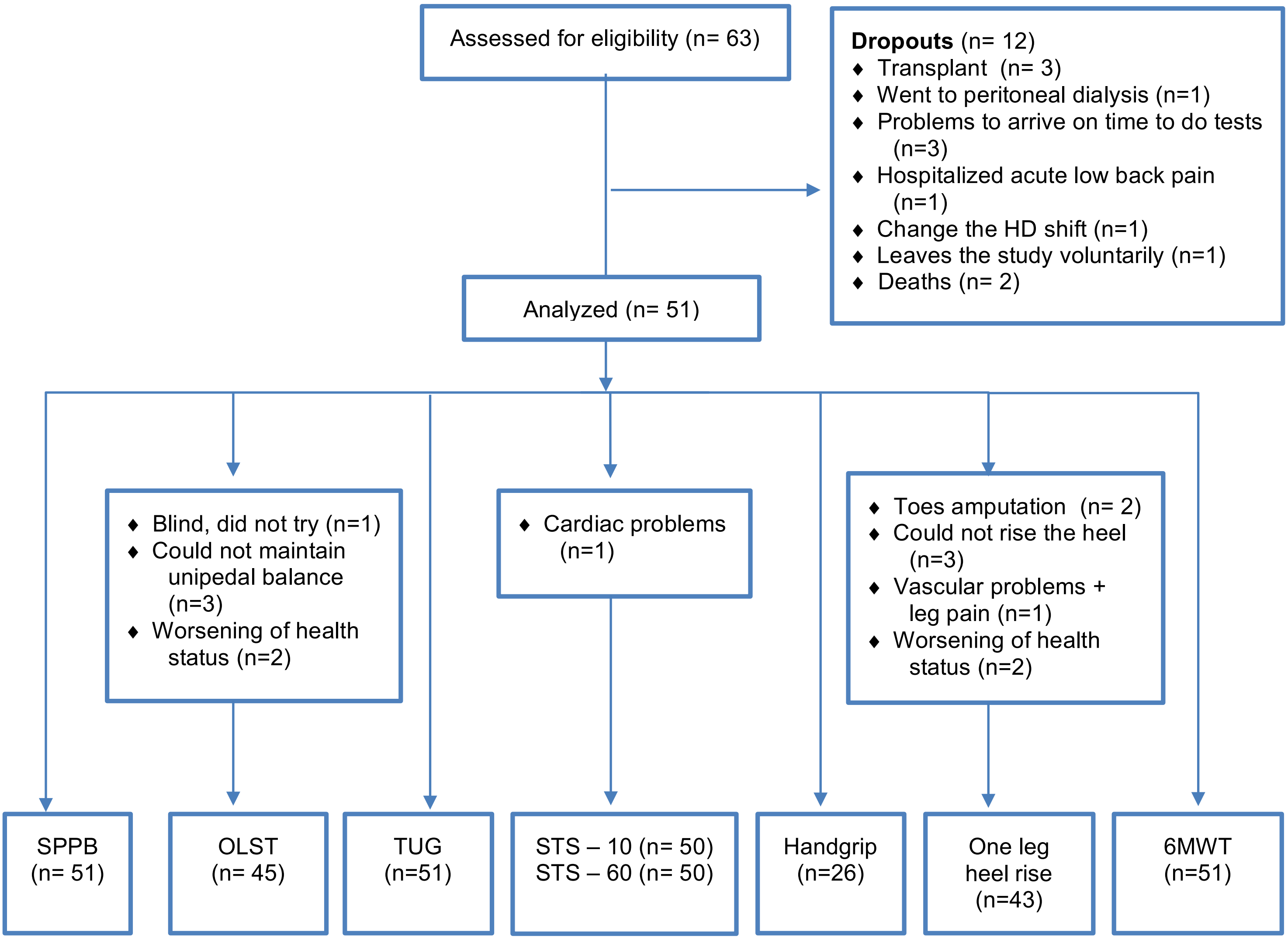
RESULTS

Fifty-one hemodialysis patients were analyzed (31 men and 20 women). The mean age of this sample was 62.9 ± 15.7 years old. The median time in hemodialysis was 56 months (minimum 13 - maximum 392 months). The Charlson Comorbidity was 6.6±2.6. The most common etiology in this group was the glomerulonephritis (12 participants) followed by the Diabetes Mellitus (11 participants) (see results in Table 5.2). The flow chart (Figure 5.1) shows the number of participants who performed each test. We had 5-drop outs (1 transplant, 2 deaths, 1 had problem to arrive at time for testing and 1 left the study voluntary). The reasons why not all the participants performed each test is in Figure 5.1. Table 5.3 shows measures at baseline and 6 months later for all tests. Only the TUG of all the physical performance tests showed a significant change after the six-months observational period (pre =8.3, minimum 0 and maximum 55) seconds; post = 8.2 minimum 0 and maximum 28.3) seconds p = 0.026 bilateral significance), but the magnitude of changes was very small (0.1s) and did not achieve a clinical relevant change. No significant changes for the others measures were found and none of them reach a clinical relevant change.

Table 5. 2 Demographics and Clinical Data for Study Participants at baseline (n=43)

Characteristic	Value
Age (mean ± SD)	62.9 ± 15.7
Sex (women:men)	20:31
Body Mass Index (kg/m2) median (minimum and maximum)	24.3 (19.6-51)
Time on haemodialysis median in months (minimum - maximum)	56 (13 – 392)
Creatinine levels (mg/dL) (mean ± SD)	9.9 ± 3.1
Hemoglobin levels (g/dL) (mean ± SD)	11.2 ± 1.4
Albumin levels (g/dL) (mean ± SD)	7.5 ± 9.1
Cause of Kidney Disease (nº of participants)	
• **Diabetes Mellitus**	11
• **Glomerulonephritis**	12
• **Nephroangiosclerosis**	3
• **Lupus**	3
• **Pyelonephritis**	4
• **Polycystic**	3
• **High Blood Pressure**	3
• **Traumatic injury of the kidney**	2
• **Others**	10
Charlson comorbidity (mean ± SD)	6.6 ± 2.6

Figure 5. 1 Flow Chart for Study Participants in Quantifying the deterioration of physical function along 6 months in patients with chronic kindey disease



SPPB: Short Physical Performance Battery; **OLST:** One Leg Standing Balance; **TUG:** Timed Up and Go; **STS:** Sit to Stand Test ; **6MWT:** 6 Minutes Walking Test

Table 5. 3 Statistical Analysis comparing the results at the beginning and at the end of the study

	N		Baseline		6-months		
Test	**Pre**	**Post**	**X (DE)**	**Mediana (min-max)**	**X(DE)**	**Mediana (min-max)**	**p**
SPPB (0-12 points)	51	51		11 (1-12)		11 (1-12)	0.578
OLST (maximum 45 seconds)	51	45	.	8.2 (0-45)		7.3 (0-45)	0.379
TUG (seconds)	51	51		8.3 (0-55)		8.2 (0-28.3)	0.026
STS – 10 (seconds)	51	50		24.2 (0-60)		25.3 (0-54.3)	0.054
STS – 60 (repetitions)	51	50	20.2 (10.1)	21 (0-48)	19.9 (9.1)	20 (0-37)	0.683
Right HG (kg)	26	26	25.4 (10.4)	25.3(7-52.5)	24.2(10.5)	20(8-52.5)	0.052
Left HG (kg)	26	26	21.3(12.1)	22.3(0-48)	21.4 (11.3)	19 (0-48)	0.643
Right One Heel Rise (Repetitions)	51	45		25 (0-25)		25 (0-25)	0.258
Left One Heel Rise (repetitions)	51	45		22 (0-25)		20 (0-25)	0.224
6MWT (metres)	51	51	390.9 (157.4)	398 (10-678)	384.7 (156.9)	396(61-706)	0.236

HG: Handgrip; **OLST:** One Leg Standing Test; **SPPB:** Short Physical Performance Battery; **STS:** Sit to Stand; **TUG:** Timed Up and Go**; 6MWT**: 6 Minutes Walking Test

DISCUSSION

To our knowledge, this is the first study that quantifies functional decline in subjects undergoing hemodialysis over 6 months. We found that only the TUG test showed a significant improvement, but it was far to reach clinical significance (0.1 seconds versus 2.9 seconds to be clinically relevant).

Pre-dialysis patients present a functional capacity decline and this decline is observed by one year after the beginning of dialysis, so that they present a reduction in activities of their daily life such as bathing or dressing (249). The decline of physical capacity is worsening along the years that a patient is in HD (82, 119, 121 – 124). Nevertheless, the rhythm at which this deterioration advances is unknown. This is the reason why this study aimed at quantifying the physical functioning decline over 6 months, and we used measures of lower extremity because it has been shown to strongly predict disability, hospitalization and mortality in older adults (195, 197).

According to our results regarding TUG, our sample is a low risk sample (201, 205) because they obtained a score < 20 seconds. However, previous researches described that 47% of CKD patients have at least one fall over one year of follow - up (205).

The lower limbs strength was indirectly measured through the STS – 10. We did not find significant differences in the time needed to stand up and sit 10 times as fast as possible at baseline versus 6 months later (pre = 24.2 minimum = 0, maximum = 60 seconds; post = 25.3, minimum 0, maximum = 54.3 seconds; p= 0.054). A previous study that reported STS-5 in hemodialysis patients after an observation period of 16 months (n= 27 patients, mean age 61.3 ± 9.0 years old) found non-significant changes (pre 12.4±0.8 seconds; post 13.6±0.9, p = 0.21) (250). Similarly, the decreased number of repetitions achieved in the STS – 60 did not reach significance (pre= 20.2 ± 10.1 repetitions; post = 19.9 ± 9.1 repetitions p = 0.68). Koufaki et al 2002 (172), included a control group that was observed, measured at baseline and after 3 months (subjects were instructed to maintain their usual level of physical activity), and results (STS – 5 pre= 12.8±4.4; post = 12.7±4.8; STS – 60 pre= 23.7±6.8; post= 24.1±7.2) neither showed differences.

Despite we did not find significant changes on the OLST and the 6MWT, we observed a decline. In a previous study (186) they followed their sample (n=18) for 12 months without doing any exercise and they did not found significant differences in the 6MWT, even that the distance walked decreased in the total sample (baseline 426±139 and 434±124 meters; after 12 months 386±152 and 410±75 meters, respectively). The control group of several studies (164) did not reach significant differences in the 6 MWT after 12 weeks. On the other hand, other studies (174) found a significant reduction in the meters walked after 16 weeks. Also, Malagoni et al 2008 (251) observed that the distance walked decreased after 6 months, but significance was achieved later in the control group (baseline 275 ± 69 meters, after 6 months 271±76 meters, after 19±3 months 204±137 meters).

We did not find significant changes in the handgrip strength, in either right (p=0.052) or left hand (p=0.643), after 6 months of observation. This result is in agreement with previous research that observed subjects for 6 months (pre = 34.1 ± 10.4 kg, post 6 months = 33.0 ± 11.9 kg) and 12 months (post 12 months = 32.3 ± 11.4 kg) (252), or 16 months (Right hand pre = 22.3 ± 2.4 kg, post 16 months = 23.9 ± 2.0 kg; Left hand pre = 20.2 ± 2.0 kg, post 6 months = 20.2 ± 2.0 kg) (250). Another study found a slight increase in the grip strength after 12 weeks (pre = 26.8 ± 8.8, post = 28.6 ± 9.0 kg) (176).

The SPPB and the one heel rise test for right land left leg neither improved nor worsened. A previous study (152), observed a control group, that did only stretching exercise with light resistance, for 48 sessions (2 times per week), and the percentage of change was 0.2 (38.4) in the SPPB score (pre = 6.0 ± 7.0; post = 6.5 ± 4.5 points). To our knowledge no other studies have been used the one heel rise test and we cannot compare our results.

These results call attention because literature reports that patients undergoing HD suffer from upper and lower limb muscles weakness (36, 38). The reasons why we have not observed a physical function decline could be related to wide age range of our sample, being the youngest participant 21 years old and the oldest 90 years old. We could guess that young subjects have better physical condition and are more active than elderly. Moreover, our sample could not represent the real population receiving HD since dialysis population include 22% oldest than 64 years, 40% oldest than 80 years and only 3.3% between 40 and 64 years old (4, 6).

Although we have not observed decline in physical functioning it is known that patients undertaking hemodialysis suffer this deterioration (38). CKD patients have high comorbidity and muscle weakness (atrophy, fatigue, lack of energy, etc.) what may lead to disability in activities of daily living and instrumental activities of daily living (190) and have higher probability to suffer falls (205).

We believe that physical functioning and physical activity level should be routinely assessed at the hemodialysis units, something that is uncommon in most of the units. This information could help to detect those subjects at risk of decreasing their physical function and physical activity at a level that affects activities of daily living, and to implement interventions to reverse this situation. Thus, it could reduce the comorbidity, the risk of hospitalization and the mortality risk.

It could be argued that 6 months is not a period long enough to modify factors that result in significant loss of physical functioning. Thus, future studies should clarify if after longer periods (12 months and above), physical functioning and physical activity significantly decrease. It would also be interesting to assess inflammatory markers, and to quantify the number of falls or to register how the deterioration affects their activities of daily living.

STUDY LIMITATIONS

The main limitation in this study was that the sample did not fully represent the old hemodialysis population, since few old participants were included.

Sometimes they did not meet the inclusion criteria and other times consent was not given by the clinician.

CONCLUSIONS

We recommended annual screening of physical performance in patients undertaking hemodialysis since after six months none of the tests performed worsened significantly. Both health professionals and patients should be informed about the importance of assessing physical performance of patients undertaking hemodialysis.

FUTURE RESEARCH

Future research should include elderly patients and achieve bigger sample. Future studies should check if there is a correlation between tests assessing falls risk and the number of falls suffered along a period of time. It would be interesting to clarify if physical functioning tests correlate with functional dependence. Also it could be interesting to quantify muscle deterioration and inflammatory markers.

CHAPTER 6. COMPARISON OF INTRADIALYTIC VERSUS HOME BASED EXERCISE PROGRAMS ON PHYSICAL FUNCTIONING, PHYSICAL ACTIVITY LEVEL, ADHERENCE AND HEALTH RELATED QUALITY OF LIFE

BACKGROUND: Patients in maintenance hemodialysis suffer from physical functioning deterioration. Previous studies have shown that supervised exercise programs are effective and safe for chronic kidney disease patients receiving hemodialysis. However, exercise is not undertaken in most hemodialysis units as a routine, and we do not know if home based programs could be as effective as intradialysis programs.

OBJECTIVE: The purpose of this study was to compare the effects of 16 weeks intradialytic versus home based exercise for hemodialysis patients regarding adherence, strength gains, functional capacity, physical activity level and health related quality of life.

METHODS: This study was a randomized trial. Patients were randomly assigned to either the intradialytic group or the home based group to receive 16 weeks of combined exercise program. Outcome measures included physical functioning tests such as the Short Physical Performance Battery (SPPB), the One Leg Standing Test (OLST), the Timed Up and Go (TUG), the Sit to Stand 10 and 60 (STS-10/60), Handgrip, the One heel rise, and the 6 minutes walking test (6MWT), 10 repetition maximum (10 RM); physical activity questionnaires such as the Human Activity Profile (HAP), and the Physical Activity Scale for Elderly (PASE); and depression and health related quality of life the Center for epidemiologic studied depression scale (CES-D) and the Kidney Disease Quality of Life 36 (KDQoL-36) at baseline and after 16 weeks.

OUTCOMES: A significant group x time interaction effect for the OLST (p= .049) and a significant time effect for the SPPB (p= .013), the TUG (p= .005),

the STS-10 (p= .027), the right hand handgrip (p= .044) and left hand (p< .001), the one heel rise for left leg (p= .019) and the 6MWT (p= .006). In the home based group, we found significant improvements in the SPPB and the TUG, while in the intradialytic group we found significant improvements in the OLST, the STS – 10, the handgrip left hand and the 6 MWT. We found a significant improvement in the activity level over time but no significant differences were found in the KDQoL. Exercise during HD resulted in higher adherence (80.8%) than the home based program (53%)

CONCLUSIONS: Both intradialytic and home based exercise programs for patients with renal failure undertaking hemodialysis improved physical function, decreased depression and increased the physical activity level. Adherence was higher in the intradialytic program.

INTRODUCTION

Chronic Kidney Disease (CKD) is one of the most common problems that we can find worldwide, being more than two million people in a renal replacement treatment (253). In Spain there are around 50.909 people in renal replacement treatment because a renal failure (6). The most frequent renal replacement treatment for CKD is Hemodialysis (HD) that replaces kidneys' function. CKD patients have a restricted daily life because they have to go the HD session approximately 4 hours per three times per week. Despite the progress in HD technique, subjects undergoing hemodialysis present functional deterioration and poor health related quality of life. In addition, this population present depression and anxiety (223, 229, 245).

Patients undergoing HD experience low physical activity compared to an age-matched population, and are described as sedentary people (94, 120). Sedentary lifestyle has been identified as major risk factors for adverse outcomes in dialysis patients (254, 255). Because of low physical activity, CKD patients are exposed to several factors that cause loss of muscle mass, muscle weakness, atrophy or fatigue, which is associated with a physical functioning reduction (97). The decreasing of physical activity and physical function have been previously associated with adverse clinical outcomes by the hemodialysis treatment (124, 128, 148), and with high comorbidity, high risk of hospitalization and reduction of lifespan that this population present (119 – 124).

Exercise programs are used since the beginning of 80's (134), and different types of exercise training has been implemented (aerobic training, strength training or a combination of both). To gain maximal benefits a combination of aerobic exercise and strength resistance has to be implemented in the exercise programs (135).

A large amount of the literature has documented the benefits from exercise improving (1) their independence and ability to perform activities of daily living (256), (2) increased maximal oxygen uptake capacity (VO_2 max) (150), (3) increased muscle mass, quality and force (35) and (4) reduce anxiety and depression (159, 162). Also different modalities of exercise have been studied in the literature (exercise in off-days dialysis, intradialytic exercise, and home base). Exercise during dialysis is described as the best modality to do exercise with this kind of patients (115, 166) because the adherence in this modality is higher compared with others (155); however, exercise programs are not implemented in most hemodialysis units (183). One of the reasons why exercise training is not implemented in HD units could be the economical burden. Home based programs could be a solution to implement exercise in CKD at lower costs (166).

Aims and Hypothesis

The aim of this study was to compare the effects of 16 weeks intradialytic versus home based exercise for hemodialysis patients regarding adherence, strength gains, functional capacity, physical activity level and health related quality of life.

METHODS

Study design

This study was a randomized controlled trial. All the eligible patients were randomly assigned to either the intradialytic group or the home based group to receive the corresponding interventions.

The intervention was 16 weeks in duration. Data was collected at two time points: at the baseline, before the intervention, and at week 16 after intervention.

Study Settings

The study was conducted from November 2014 to July 2015 in two-hemodialysis units in Valencia (Spain). The dialysis practice in the two centers was similar. In one center three shifts of hemodialysis treatments were set on Monday, Wednesday and Friday (morning, afternoon and night shift), but we could get access only to the morning and the night shift; on Tuesday, Thursday and Saturday there were two shifts (morning and afternoon shift) but we had access only to the morning shift. In the second dialysis center two shifts of hemodialysis treatment were set from Monday to Saturday- the morning and afternoon shifts.

Ethical considerations

The Ethics Committee from *Hospital Universitario Doctor Peset* approved the study, and this study was carried out within the ethical standards set forth in the Helsinki Declaration of 1975. All participants were informed of the purpose, procedures and confidentiality of the study. It was made clear to them that their participation was voluntary and that they could withdraw from the study at any time without penalty. Written informed consent was obtained from all subjects. This study was registered in Clinical trials with the number NCT02832440.

Participants

Subjects were assessed by the physician in-charge to ensure that they were able to perform the recommended exercise, giving authorization before solicitation of interest according to inclusion criteria. Patients were eligible to participate if they were at least 3 months in hemodialysis.

Exclusion criteria were: (1) recent myocardial infarction (within 6 weeks), (2) unstable angina, (3) malignant arrhythmias, (4) above the knee amputation without replacement, (5) cerebral vascular disease (ictus, transient ischemia), (6) musculoskeletal and respiratory disorders that can get worse with exercise and (7) impossibility to achieve functional testing.

Those patients who met the criteria for eligibility were invited to participate in the study.

Randomization and blinding

Participants who completed the baseline data evaluation were randomly assigned to either the intradialytic group or the home based group using blocked randomization by gender and age (http;//www.randomization.com) and the allocation was concealed.

The data collectors were blinded to the random assignment throughout the whole study period.

Outcomes measurements and tools

The clinical and anthropometric characteristics of participants were collected from the medical history, in which were recorded the clinical diagnosis, indicating renal disease, age, gender, body mass index (BMI), time on hemodialysis, smoking habits, hemoglobin creatinine and albumin levels, and the Charlson comorbidity scale.

Physical Functioning test

All the data were collected at the beginning (baseline) and at the end of the study (after 16 weeks).

For more detailed information about the physical performance test see CHAPTER 2. GENERAL METHODS.

Short Physical Performance Battery (SPPB)

The Short Physical Performance Battery (SPPB) was performed immediately before the first hemodialysis session of the week. It is an easy test to evaluate physical function in lower limbs. It consists of standing balance (side-by-side, semi-tandem and tandem position), gait speed 4 meters and the sit to stand-5 test. The SPPB is scored from 0 to 4 points in 3 sections, so that the total score ranges from 0 to 12 points, with a higher score representing better physical performance. The SPPB scores have been widely using as predictor of disability, recurrent hospitalization, institutionalization and death in general population (195, 197). Prior to the study we calculated the intraclass correlation (ICC) and the minimal detectable change (MDC) (ICC = 0.94, 95% confidence interval = 0.91-0.97 and MDC_{90}= 1.7 points) (CHAPTER 4. TEST – RETEST RELIABILITY AND MINIMAL DETECTABLE CHANGE SCORES FOR THE SHORT PHYSICAL PERFORMANCE TEST, ONE LEG STANDING TEST AND TIMED UP AND GO IN PEOPLE UNDERGOING HEMODIALYSIS).

One leg Standing Test (OLST)

The one leg standing test (OLST) was performed immediately before the first hemodialysis day of the week. The subject was allowed to choose the leg they preferred to complete the test. If they were having pain or other symptoms in the first leg, they were permitted to use the other leg. They had to maintain one leg stance for as long as possible (maximum 45 seconds) with eyes open, and their arms were allowed to move freely. All subjects wore shoes. The participants were given three trials to achieve 45 seconds. During each trial the subjects were verbally encouraged to maintain one leg stand position for as long as possible.

The test concluded when the participant used their arms to touch the wall, if the foot touched the ground, if the subject moved the standing foot or when time arrived to 45 seconds (199). Prior to the study we calculated the ICC and the MDC (ICC = 0.90, 95% confidence interval = 0.83 – 0.94, and the MDC_{90}= 11.3 seconds) (CHAPTER 4. TEST – RETEST RELIABILITY AND MINIMAL DETECTABLE CHANGE SCORES FOR THE SHORT PHYSICAL PERFORMANCE TEST, ONE LEG STANDING TEST AND TIMED UP AND GO IN PEOPLE UNDERGOING HEMODIALYSIS).

Timed Up and Go (TUG)

The Timed Up and Go test (TUG) was performed immediately before the first hemodialysis session of the week. Subjects were given verbal instructions to stand up from a standard arm chair using the arms if needed, walk three meters as quickly and safely as possible, turn back the cone, walk back and sit down to the chair. Participants were allowed to wear their regular footwear, and to use walking aid if needed. A stopwatch was started on the “go” and stopped when fully sitting position that back against the backrest was reached again. The time taken to complete the test was measured in seconds and the best of the three trials was used of analysis (203, 204). We calculated the ICC and the MDC (ICC = 0.96, 95% confidence interval = 0.94-0.98, and MDC_{90} = 2.9 seconds) (CHAPTER 4. TEST – RETEST RELIABILITY AND MINIMAL DETECTABLE CHANGE SCORES FOR THE SHORT PHYSICAL PERFORMANCE TEST, ONE LEG STANDING TEST AND TIMED UP AND GO IN PEOPLE UNDERGOING HEMODIALYSIS).

Sit to Stand 10 and Sit to Stand 60 (STS – 10/STS – 60)

Both tests were performed immediately before the second hemodialysis day of the week.

Firstly, we performed the STS – 10 (sit to stand 10) and after 10 minutes we performed the STS – 10 (sit to stand 60), when heart rate and blood pressure had decreased to baseline levels.

The STS – 10 consists of measuring the time in (in seconds) required to perform 10 consecutive repetitions of getting up and sitting down from a standard chair (approximate seat high of 46 cm, arm high 65 cm). The test starts and finishes at the sitting position. They had to cross their arms on their chest and sitting with their back against the chair. Subjects were instructed to perform the task “as fast as possible”. Participants were allowed a practice trial before the beginning of test.

The STS – 60 consists of measuring the number of repetitions of getting up and sitting down from a chair, with arms folded across their chest, achieved in sixty seconds. Each repetition started and finished at the sitting position, and if a participant was standing when the time was over, it was considered half a repetition. Participants were allowed to stop if rest was needed and to continue performing the task until the 60 seconds were over. Participants after each test described the degree of difficulty, determined by the rate of perceived exertion (RPE), measured with the Borg Scale from 6 to 20.

The test-retest reliability of the STS – 10 and STS – 60 is excellent in patients undergoing hemodialysis (ICC=0.88, 95% confidence interval = 0.78-0.94 and ICC = 0.97 95% confidence interval = 0.94-0.98 respectively) and the MDC for the STS – 10 is 8.4 seconds while for the STS – 60 is 4.0 repetitions (118).

One leg heel rise

This test was also performed immediately before the second hemodialysis session of the week. To perform this test subjects must wear only socks (no foot-wear). We used a metronome to keep the rhythm, one lift every second. To perform the test participants had to touch the wall with their fingers tips, with arms in abduction. Participants were asked not to push their arms against the wall and thereby shifting their weight. Before the test, participants were asked to maintain balance while standing on one leg. The contralateral foot was held just above the floor. The participants were allowed to have one trial to become familiar with testing procedure. The participants were instructed to lift the heel as high as possible at the metronome rhythm until no further heel rises could be performed due to exhaustion. The test finished if the participant leaned or pushed against the wall or their keens were flexed, according to the examiner's observation. Also they were instructed to perform a maximum of 25 repetitions because it is considered the average number of repetitions performed by healthy population (214, 215). They had to perform the test with both legs and we recorded the degree of difficulty determinate by RPE.

This test has shown excellent test-retest reliability, with ICC for the right leg = 0.97, 95% confidence interval = 0.92-0.99; ICC for the left leg = 0.94, 95% confidence interval = 0.85-0.97 and MDC right leg = 3.7 and MDC for the left leg =5.2 repetitions (118).

Handgrip Strength dynamometer

Before the second hemodialysis session of the week, subjects performed the handgrip strength test with a handgrip dynamometer (JAMAR Sammons Preston Rolyan, Chicago, Illinois, USA) to measure the amount of strength developed by each hand. Participants were positioned sitting in a chair with feet touching the floor with knees 90º flexed, shoulder in neutral rotation, elbow flexed in 90º lean against the table, wrist and forearm semi pronated (0-30º) and wrist in ulnar deviation between 0 – 15º, and proximal inter phalangeal articulations in 90º.

They started always with the dominant hand. They performed the test three times per hand, with an interval of 15 seconds between repetitions to avoid muscle fatigue. The instructions were to press progressively and maintain pressure during 3 seconds (118, 211, 212, 246 247).

This test has shown excellent test-retest reliability in young healthy population (ICC= 0.822) (211), while test-retests reliability in chronic kidney disease has shown excellent for dominant and non-dominant hand (ICC = 0.96, 95% confidence interval = 0.88-0.99 and ICC = 0.95, 95% confidence interval = 0.83-0.98, respectively) being the MDC 3.4 kilograms for dominant and non-dominant hands (118).

Six Minutes Walking Time (6MWT)

Immediately before the third hemodialysis session was performed the six minutes walking test, because by the end of the week, the extra fluid retained by the participants was at its lowest level, minimizing its influence on the test results. The 6MWT was performed in a 20-30 meters' corridor located in the hemodialysis unit. Tape was placed every two meters.

Participants were asked to walk the longest distance possible in 6 minutes by walking continuously the 20 or 30 meters indicated on the floor, turning around at the final mark without stopping. The standardized order given to participants, following the American Thoracic Society (ATS 2002) instructions was "walk as far as possible for 6 minutes, but do not run or jog". They were allowed to use any walking aid if necessary. They could turn down their velocity or stop if needed and restart later. Heart rate and blood pressure were measured before and immediately after the test. We recorded the distance covered and the degree of difficulty determined by the RPE at the end of the test (118, 202 217, 248).

The test has shown excellent reliability in adults with chronic kidney disease (ICC=0.94) and the MDC in this test was 66.3 meters (118).

The 10 Maximum Repetition

The 10 maximum repetitions (10-RM) method can be defined as the maximum amount of weight lifted ten times. Subjects were seated in a chair with the back against the backrest. Participants were asked to extend both knees from standardized position 90º-flexed knees until 0º keeping limb horizontal, with attached weights applied to the ankle (218). The rhythm for this exercise was two seconds of concentric contraction, two seconds of isometric contraction and four seconds of eccentric contraction, without pauses between each repetition. The initial weight was standardized among subjects and when the weight was successfully lifted the weight for the next trial was incremented by 0.5 to 2.5 kg (219). They were asked for the perceived effort by the RPE. One-minute recovery was to avoid fatigue in the muscle. The test stopped when in the last trial they perceived and effort of 12-13 in the RPE. The test was performed every two weeks to adapt the weight lifted during the exercises to the increased strength (145).

Questionnaires

Different questionnaires were used to quantify the physical activity level, depression and health related quality of life. The patients filled the questionnaires during the HD session with assistance of a researcher.

Human Activity Profile (HAP) and Physical Activity Scale for Elderly (PASE)

To evaluate the physical activity level, the participants were asked to complete two questionnaires, the Human Activity Profile (HAP) and the Physical Activity Scale for Elderly (PASE). Both questionnaires had been validated in the population with renal disease (223).

The HAP questionnaire consists of a list of 94 items, which assesses activities ranked in ascending order of level of energy (for example number 1 is "getting in and out of chairs or bed without assistance" to number 94 "jogging three miles within 30 minutes"). The participants had three possibilities to answer: (1) still doing this activity, (2) have stopped doing this activity, or (3) never did this activity. The HAP assesses the Maximal activity score level of activity (MAS) (the highest level of activity) and the adjusted activity score (ASS). The MAS is calculated as the activity with the highest oxygen consumption requirement that the subject still performs, while the ASS is the difference between the MAS and the number of less demanding activities the subject has stopped performing. The ASS gives us a better estimate of the range activities performed and of the presence of impairment. For example, a subject which his/her vigorous activity he/she can still doing is “climbing 36 steps” which is item 60, the MAS it would be 60. However, if the subject has stopped performing ten activities that are less strenuous that climbing 36 steps, then the AAS would be 50. Depending on the AAS, subjects can be classified as impaired activity (AAS less than 53), moderately active (AAS 53-74) or active (AAS greater than 74) (221).

On the other hand, the Physical Activity Scale for Elderly (PASE) assesses the activity performed during the previous week. Subjects had to report the amount of time they spent doing a specific type of commonly performed by the elderly activities (leisure time, household, and work-related activity). Each activity is assigned a weight that is derived from a sample of 277 older adults using a combination of accelerometer data, metabolic equivalent-task (MET) values from daily activities. The total score is recorded as the sum of the amount of time that the person spends in each activity (hours per week) multiplied by the weight designed to each activity (224).

Depression Symptoms Assessment

The Center for Epidemiologic Studies Depression scale (CES-D) is a validated, self-report questionnaire comprising 20 questions of depressed mood. Subjects respond to the CES-D by rating each item in terms of the frequency that each mood occurred “during the past week” on a four point-scale, ranging from 0 to 3 (“none of the time”, “most of the time”, respectively). The total score ranges from 0 to 60 points with higher scores indicating greater degrees of depression symptoms (226). Participants with a score ≥ 16 points are considered at risk for depression in the general population (225).

Kidney Disease Quality of Life – 36 (KDQoL – 36)

To assess health related quality of life in patients with chronic kidney disease, we used a specific questionnaire for this population, the Kidney Disease Quality of Life Short Form 36 (KDQoL– 36). It was validated to assess HRQoL in ESRD on HD patients (227).

The KDQoL – 36 consists in 36 items that describes the perception of health state during the last 4 weeks leading to five dimension such as (1) Symptoms and problems, (2) effects of kidney disease on daily life, (3) Burden of Kidney disease, (4) the Short Form-12 Physical Composite and (5) the Short Form 12 Mental Composite. The maximal score per each category is 100 point. A higher score indicates better-perceived health state (227).

This Spanish version questionnaire has been shown to be valid and reliable, with an ICC ranging from 0.62 to 0.77 for each dimension (229).

INTERVENTION

Subjects were randomized into two groups: the intradialytic group and the home based group. Both interventions lasted 16 weeks, and are detailed in Figure 6.1.

Figure 6. 1 The intervention for the trial groups

	Intradialytic Group	Home Based Group
16 weeks	**Warm-up 5 minutes** - Stretching lower limbs (Triceps sural, hamstring, external rotator muscles) **Main part** ***1. Strength training*** - Quadriceps exercise - Triple extension (hip, knee, ankle) - Triceps sural - Adductors - Hamstring ***2. Aerobic training*** - Cycling **Cool-down 5 minutes** - Stretching lower limbs	**Warm-up 5 minutes** - Stretching lower limbs **Main part** ***1. Strength training*** - Quadriceps exercises - Hamstring exercise - Gluteus exercise - Triceps sural exercise - Abductors exercise ***2. Balance training*** ***3. Aerobic training*** - Walking **Cool-down 5 minutes** - Stretching lower limbs

Exercise during dialysis. Intradialysis exercises program

Each session was supervised and assisted by a physical therapist and took place during the first two hours of the three routine HD sessions per week to avoid physical stress in the second half of the session, when the patients' hemodynamic conditions are unfavorable. Several studies, found that after the first two hours of HD, exercise may cause arterial hypotension (167 – 169).

Each session consisted of a short warm-up, a main part, and a cool down. The exercises were performed in seated or supine position, depending on the HD treatment position.

The session started (warm-up) and finished (cool-down) with five minutes of stretching, including assisted stretching of triceps sural, hamstring and external rotator muscles.

The main part consisted of five progressive isotonic and isometric resistance exercises that specifically targeted major muscle group of the lower limbs. Participants performed 1 set of 10 and progressed until 15 repetitions of each exercise.

The first exercise consisted of extending one knee from a standardized position 90º flexed knee until 0º keeping limb horizontal, with attached weights applied to the ankle. The rhythm for this exercise was two seconds of concentric contraction, two seconds of isometric contraction and four seconds of eccentric contraction, without pauses between each repetition (114). The weight was set according to the 10 RM (maximum repetition). To increase the difficulty, we increased the weight every two weeks around 0.5 to 2.5 kg.

The second exercise consisted of a unilateral extension of the hip, knee and ankle (triple extension) with an elastic band starting with a standardized position with 90º of flexion in the hip, knee and ankle (114). The elastic band was fixed at metacarpal heads level of the shoes. The exercise consisted of two seconds for extending hip, knee and ankle and two seconds for flexing these three joints. The progression was achieved by changing the color of the band and by doubling the elastic band.

The third exercise consisted of an eccentric exercise for triceps sural with an elastic band fixed at metacarpal heads level of the shoes. It consisted of ankle extension in one second and ankle flexion in two seconds. Progression was adjusted by the color of the band and by doubling elastic band (114).

Fourth and fifth exercises consisted of an isometric contraction of the adductors and hamstring muscles. Patients were asked a bilateral maximal contraction from a standardized hip position, knee flexion and ankle flexion. For the adductors isometric contraction, the patient had a ball between knees and for the hamstring isometric contraction the ball was between heels and the chair or bed (depending on patient's position). They had to maintain the contraction for three seconds and progression was achieved by increasing contraction time up to six seconds. Proper breathing technique was emphasized during all exercises to avoid Valsalva maneuver, as recommended by previous research (230).

After these strengthening exercises patients had to cycle (cycle ergometer Mottomed Letto) and intensity was adjusted by the RPE. Subjects had to perceive the exercise as something hard according to subjective tolerance. The cycling exercise duration was 10 minutes by the beginning of the program, and was increased up to 30 minutes within a few sessions. The last two weeks the cycling time increased up to 45 minutes in those who could achieve it. The cycle ergometer displays some information and gives feedback to motivate subjects, such as revolutions per minute, power developed and distance virtually travelled (232).

The intensity for both strength and aerobic exercises was set by the rate of perceived exertion (RPE) Borg Scale at level between 12 and 15. Participants should feel the exercise not less than 12 at the RPE, but less than 15 at the RPE, so that intensity involved 65% to 85% of individual's maximal capacity

(231). Heart rate and blood pressure was monitored every 15 or 30 minutes depending on how the HD machine was programmed.

Home Based exercise program

The Home Based (HB) training program included a warm-up and cool-down plus the main training. The participants were asked to exercise at least three times per week, they could choose dialysis days or non-dialysis days, always trying to have a day off between each session, at any time of the day. The physical therapist planned to go to every patient's house to explain the exercise in their daily environment, to supply them with a weight to do the exercise program according to the 10 RM and to meet their family members to explain them the importance of exercising. The sessions were discussed with a physical therapist during every hemodialysis session for the first four weeks and weekly for the rest of the time. This person solved questions that patients could have, asked them if they were doing the exercise and motivated them to continue with the exercise program. Even that participants from the home based program were asked to complete a diary writing regarding how long they were training, the weight they lifted, the time they were walking and the heart rate plus blood pressure at the beginning and at the end of the training session, the physical therapist also interviewed participants regarding adherence to the exercise program.

The warm-up and the cool-down consisted of five minutes of stretching (triceps sural, hamstrings, adductors, quadriceps), depending on the ability of each subject. The main part of the program consisted of lower limbs exercises with the weight set according to the 10 RM, and included exercise for quadriceps, hamstrings, triceps sural, gluteus and abductors. Strength prescription started from 1 set per 10 repetitions and progressively increased to 3 sets per 8 – 10 repetitions. They had to walk during one minute as fast as they could without running or jogging in between each strengthening exercise. Subjects also performed balance exercises, doing side-by-side, semi-tandem, tandem or one leg stance position, depending on their physical conditioning. They had to maintain each position 10 seconds and they were asked to performed 1 set of 3 repetitions per each leg, but if the subject was able to maintain the 10 seconds he/she was asked to maintain that position for as long as possible. Each exercise could be modified if the patient felt it easy to according to the RPE.

The intensity for all the exercise was adjusted by the degree difficulty according to the rate of perceived exertion (RPE) Borg Scale at level between 12 (not less than “somewhat hard) and 15 (“hard” according to the RPE). Strength prescription started from 1 set x 10 repetitions and progressively increased to 3 sets x 8 – 10 repetitions. Total time of the program was 45 minutes per session.

Participants were asked to walk at normal speed at least 3 times per week between 15 – 30 minutes at normal speed. Posteriorly, they had to stretch posterior muscles of the lower limbs.

Adherence to exercise programs

Adherence to treatment was defined as the number of sessions performed by the number of sessions offered, multiplied by 100. Subjects were included in the analysis if they performed, at least, 50% of the sessions offered.

To motivate participants a whiteboard with participants’ names was located at the dialysis unit. In each whiteboard two paths were draw (one path for the intradialytic group, and the second way for the HB group) with the exit line and the finish line. Each participant was move depending on the exercise that he/she had performed each week. Another strategy to increase adherence was to deliver a medal by the end of the intervention to participants who followed the program.

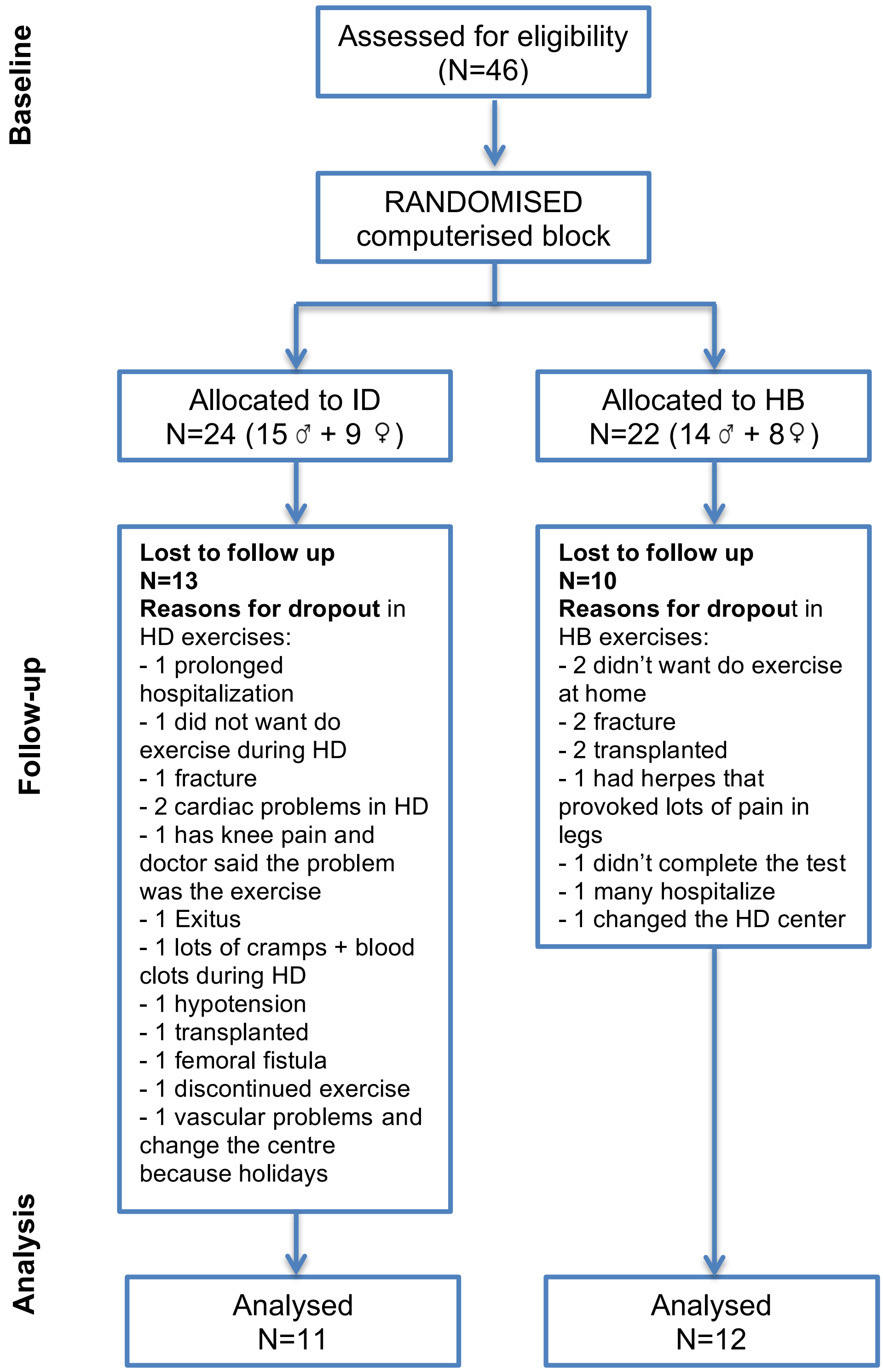
Statistics

Normal distribution of data was checked through the Kolmogorov-Smirnov test, skewness and kurtosis. Results are presented as median (minimum-maximum) or mean (standard deviation). Non-parametric Mann-Withney U test was used to check difference between groups at the beginning. To analyze the effect of the exercise programs we used the ANOVA mixed test, with time as within group factor and the exercise group as between group factor. The SPSS package version 20.0 for Windows was used to the statistical analyzed, recognizing significant results to be $P \leq 0.05$ for all statistical analyses.

RESULTS

Forty-six hemodialysis patients were recruited and randomly allocated into two groups: intradialysis group (GI) (n=24; 15 men and 9 women) and home based group (HB) (n= 22; 14 men and 8 women). At the end of the study we analyzed data of 23 participants (GI=11 and HB=12). Figure 6.2. There were 13 dropouts in the intradialysis group and 10 in the home based group (Figure 6. 2).

Figure 6. 2 Flow Chart for Study Participants in the Comparison of intradialytic versus home based exercise programs on physical functioning, physical activity level, adherence and health related quality of life



ID group: Intradialytic group; **HB group:** Home based group, **HD:** Hemodialysis; ♂: Males; ♀: Females

Baseline demographics and clinical characteristics

Baseline descriptive characteristics of all participants are summarized in Table 6.1. No significant differences were found between groups, indicating successful randomization of participants.

In the ID group the mean age was 65.3±15.2 years old; there were more males (62.5%) than females; and the average duration for dialysis was 32 months, ranging from 18 to 131 months. The Charlson Comorbidity was 6.6±2.8. Creatinine level 6.7±3.4 mg/dL, hemoglobin level 10.8±0.8 g/dL and albumin level 3.6±0.4 g/dL. In the HB group the mean age was 61.9±12.3 years old; there were also more males (63.6%) than females; and the average duration for dialysis was 67.5 months, ranging from 21 to 194 months; and the Charlson Comorbidity was 6.0±2.0. Creatinine level 7.9±3.9 mg/dL, hemoglobin level 10.5±1.7 g/dL and albumin level 3.7±0.3 g/dL.

Glomerulonephritis (26.1%) was the major cause of their renal failure followed by Diabetes Mellitus (17.4%).

Table 6. 1 Baseline demographic and clinical characteristics (n=46)

Characteristic	Value HD exercise	Value HB Exercise	Total	P-value
Age (mean ± SD)	65.3±15.2	61.9±12.3	63.52±13.5	0.56
Sex (women:men)	9:15	8:14	17:29	0.76
Weight (kg) (mean ± SD)	73.6±13.9	70.5±17.1	72.1±15.4	0.51
Height (m) (mean ± SD)	1.66±0.08	1.67±0.1	1.66±0.09	0.62
Body Mass Index (kg/m2) median (mean ± SD)	26.6±3.7	25.1±5.3	25.9±4.5	0.10
Time on hemodialysis. Median (minimum-maximum) in months	32(18-131)	67.50(21-194)		
Creatinine levels (mg/dL) (mean ± SD)	6.7±3.4	7.9±3.9	7.3±3.7	0.37
Hemoglobin levels (g/dL) (mean ± SD)	10.8±0.8	10.5±1.7	10.7±1.3	0.56
Albumin levels (g/dL) (mean ± SD)	3.6±0.4	3.7±0.3	3.7±0.3	0.46
Primary cause for renal failure (n of participants)				
• **Diabetes Mellitus**	3	5	8	
• **Glomerulonephritis**	4	8	12	
• **Nephroangiosclerosis**	2	1	3	
• **Lupus**	3	-	3	
• **Pyelonephritis**	1	1	2	
• **Polycystic**	1	-	1	
• **High Blood Pressure**	3	-	3	
• **Traumatic injury of the kidney**	-	2	2	
• **Others**	7	5	12	
Charlson Comorbidity(mean ± SD)	6.6±2.8	6.0±2.0	6.3±2.5	0.25

Effects of the intervention in the physical functioning test

The results of the two-way ANOVA (table 6.2) showed a significant group x time interaction effect for the OLST (p= .049, η_p^2= .189). In addition, ANOVA revealed a significant time effect (baseline vs 16 weeks intervention) for the SPPB (p= .013, η_p^2= 0.261), the TUG (p= .005, η_p^2= 0.316), the STS-10 (p= .027, η_p^2= 0.221), the right hand handgrip (p= .044, η_p^2= 0.179) and left hand (p< .001, η_p^2= 0.464), the one heel rise for left leg (p= .019, η_p^2= 0.314) and the 6MWT (p= .006, η_p^2= 0.307) indicating that performance improved in both intervention groups.

The within-group analysis reported significant improvements in the home based group in the SPPB (1 point, 95% confidence interval (CI) = 0.12 – 1.21; p= 0.019) and the TUG (0.4 seconds, 95% CI = -0.66 – -0.08; p= 0.013). In the intradialytic group we found significant improvements in the OLST (5.9 seconds, 95% CI=1.42– 10.55; p=0.013), the STS – 10 (3.1 seconds, 95% CI= -6.04 – -0.15, p=0.041), the handgrip left hand (2.1 kg, 95% CI= 1.03 – 3.31; p=0.001) and the 6 MWT (25.5 meters, 95% CI= 2.83 – 48.07; p=0.029).

Table 6. 2 Significance by ANOVA of the physical functioning tests

Variable	Group	Mean ± standard deviation		Analysis of variance (group x time), P-value	Effect size	Analysis of variance (time), P-value	Effect size
		Baseline	After 16 weeks				
SPPB (points) Mean (SD)	ID HB	10.6 (1.43) 10.1 (2.3)	11 (1.6) 10.8 (2.1)	F=0.643, .432	0.030	F=7.433, .013	0.261
OLST (seconds) Mean (SD)	ID HB	12 (14.1) 17.2 (19.4)	17.9 (18.4) 16.6 (19.8)	F= 4.421, .049	0.189	F= 2.829, .109	0.130
TUG (seconds) Mean (SD)	ID HB	7.9 (1.7) 9.5 (2.5)	7.6 (1.6) 9.1 (2.2)	F= 0.405, .531	0.019	F= 9.717, .005	0.316
STS-10 (seconds) Mean (SD)	ID HB	25.4 (10.6) 25 (10.7)	22.3 (7.2) 23.6 (8)	F=0.726, .404	0.035	F= 5.678, .027	0.221
STS-60 (repetitions) Mean (SD)	ID HB	19.7 (7.4) 21.6 (7.7)	23.6 (8.2) 20.8 (3.7)	F=3.911, .062	0.164	F=1.795, .195	0.082
HG R hand (Kg) Mean (SD)	ID HB	27.8 (11.8) 29.3 (11.7)	30 (9.4) 30.3 (11.1)	F=0.546, .468	0.025	F=4.577, .044	0.179
HG L hand (Kg) Mean (SD)	ID HB	26.6 (9.7) 25.8 (11.5)	28.7 (9.6) 26.9 (10.7)	F=2.061, .166	0.089	F=18.212, .000	0.464
One Heel Rise R Leg (repetitions) Mean (SD)	ID HB	23.3 (2.5) 18.5 (9.2)	23.6 (3.6) 18.9 (9.4)	F=0.000, .995	0.000	F=0.144, .709	0.008
One Heel Rise L leg (repetitions) Mean (SD)	ID HB	21.6 (4.8) 17.3 (10.1)	24.7 (1) 20.1 (9.5)	F=0.011, .919	0.001	F=6.862, .019	0.314
6MWT (meters) Mean (SD)	ID HB	410.7 (107.9) 360.7 (126.7)	436.2 (100.5) 381.2 (96.2)	F=0.108, .745	0.005	F=9.314, .006	0.307

HB: Home based group; **HG:** Handgrip; **ID:** Intradialytic group; **L:** left **OLST:** One Leg Standing Test; **R:** right **SPPB:** Short Physical Performance Battery; **STS:** Sit to Stand; **TUG:** Timed Up and Go; **6MWT:** 6 minutes walking test;

Effects of the intervention in the physical activity level

HAP AAS shows a significant improvement over time (baseline vs 16 weeks intervention p=0.011, η_p^2= 0.268), but no significant differences were found within groups.

Also we found a significant time effect in the PASE (p=0.001, η_p^2= 0.427). Regarding intra group effect, both intervention groups improved (intradialytic group changed 26.6 points, 95% CI = 7.39 – 45.78; p= 0.009, while the home based changed 23.9 points, 95% CI = 5.61 – 42.4; p= 0.013).

Table 6.3 represents the ANOVA results from the physical activity level

Effects of the intervention in the depression variable

In the CES-D, there were found significant changes only in the time factor (p=0.017, η_p^2= 0.244), but just the intradialytic group improved significantly (5 points, 95% CI= -10.52 – -2.03; p= 0.006).

Effects of the intervention in the health related quality of life

No significant effects were found (see Table 6.5).

Adherence to exercises program

Adherence to exercise programs achieved 80.8% of the total in the intradialysis exercise group, while the home based group achieved the 53% of the total. Only 2 participants from the home based group allowed the physical therapist to attend a home session to explain the exercise in the daily environment and provided them with the necessary material.

Table 6. 3 Significance by ANOVA of the physical activity level

Variable	Group	Mean ± standard deviation		Analysis of variance (group x time), P-value	Effect size	Analysis of variance (time), P-value	Effect size
		Baseline	After 16 weeks				
HAP MAS (points) Mean (SD)	ID HB	58.9 (17.9) 49.5 (18.1)	63.6 (19,3) 50.6 (19.9)	F= 1.501, .234	0.067	F=3.890, .062	0.156
HAP AAS (points) Mean (SD)	ID HB	42.1 (32.6) 21.5 (30.6)	50.2 (27.2) 28.67 (27.9)	F=0.028, .868	0.001	F=7.690, .011	0.268
PASE (points) Mean (SD)	ID HB	112.1 (113.7) 59.4 (39.9)	138.6 (113.1) 83.4 (53.1)	F=0.041, .842	0.002	F=15.642, .001	0.427

AAS: Adjusted Activity Score; **HAP:** Human Activity Profile; **HB:** Home based group; **ID:** Intradialytic group; **MAS:** Maximal Activity Score; **PASE:** Physical Activity Scale for Elderly

Table 6. 4 Significance by ANOVA of the depression

Variable	Group	Mean ± standard deviation		Analysis of variance (group x time), P-value	Effect size	Analysis of variance (time), P-value	Effect size
		Baseline	After 16 weeks				
CES-D (points) Mean (SD)	ID HB	15.5 (13.2) 15.6 (9.9)	9.2 (8.7) 14.5 (8.1)	F=3.370, .081	0.138	F=6.772, .017	0.244

CES – D: Center for Epidemiologic Studies Depression scale; **HB:** Home based group; **ID:** Intradialytic group

Table 6. 5 Significance by ANOVA of the Health Related Quality of Life

Variable	Group	Mean ± standard deviation		Analysis of variance (group x time), P-value	Effect size	Analysis of variance (time), P-value	Effect size
		Baseline	After 16 weeks				
Symptoms and problems list (points) Mean (SD)	ID HB	83.9 (12.5) 81.9 (10.7)	87.7 (11.3) 80.9 (12.4)	F=2.375, .138	0.102	F=0.738, .400	0.034
Burden of kidney disease (points) Mean (SD)	ID HB	51.7 (29.1) 40.1 (15.9)	51.7 (31) 43.2 (22.7)	F=0.163, .691	0.008	F=0.163, .691	0.008
Effects of kidney disease on daily life (points) Mean (SD)	ID HB	73.6 (16.8) 78.6 (19.1)	65.3 (23.9) 75 (21.2)	F=0.392, .538	0.018	F=2.625, .120	0.111
Physical component summary (points) Mean (SD)	ID HB	42.04 (10.4) 40.9 (8.6)	45.7 (11.2) 41.8 (12.8)	F=1.172, .291	0.053	F=2.865, .105	0.120
Mental component summary (points) Mean (SD)	ID HB	49.9 (9.5) 47 (10.3)	50.3 (8.1) 49.9 (11.1)	F=0.772, .390	0.035	F=1.177, .290	0.053

ID: Intradialytic group; **HB:** Home based group

DISCUSSION

We found a significant improvement for all participants in most of the physical functioning tests (SPPB, TUG, STS-10, bilateral handgrip strength, left one leg standing test and the 6 MWT) which means that a combined exercise program in CKD patients undergoing hemodialysis is effective to enhance physical functioning. Additionally, all participants improved the physical activity level (HAP AAS and PASE results) and depression (CES – D), but no effect was found on HRQoL. The within group analysis showed that most of the variables improved significantly only in the intradialytic exercise group (OLST, STS-10, handgrip, 6MWT, PASE, CES – D), while only the SPPB, TUG and PASE results improved significantly over time in the home based group. Only a significant group per time interaction was found on the OLST.

Previous studies concluded that exercise interventions result in functional capacity, health related quality of life and psychological improvement of this cohort (135, 136, 271). Most of these studies focused predominantly on aerobic physical exercise during HD sessions, although recently strengthening or endurance exercise has been also implemented (114, 137, 138, 166, 209).

Despite exercise benefits are described at the *National Kidney Foundation KDOQI guidelines of exercise training in CKD patients*, and despite the recommendations that “all dialysis patients should be counseled and regularly encouraged by nephrology and dialysis staff to increase level of physical activity” (177), this treatment is rarely implemented in the patients’ care routine at the HD units. One of the reasons why exercise training is not implemented in HD units can be the economic burden. Home based programs could be a solution to implement exercise in CKD at lower cost (166).

For this reason, our purpose was to compare the effects of 16 weeks intradialytic versus home based exercise for hemodialysis patients.

Effectiveness of 16 weeks combined exercise program on physical function

There is a significant improvement in time effect in the SPPB, the TUG, STS-10, the handgrip in both hands, in the one heel rise only in the left leg and in the 6MWT, which means that a combined exercise program in CKD patients is effective to enhance physical functioning.

Regarding SPPB results, we found an increase of 1 point in both groups, but only the home based reached significance. Nevertheless, we analyzed STS – 5 and walking speed separately, and we found a time effect only for the STS – 5, that was significant only in the intradialysis exercise group (results not shown). The change in the total score did not achieve a clinically meaningful change set at 1.7 points (CHAPTER 4. TEST – RETEST RELIABILITY AND MINIMAL DETECTABLE CHANGE SCORES FOR THE SHORT PHYSICAL PERFORMANCE TEST, ONE LEG STANDING TEST AND TIMED UP AND GO IN PEOPLE UNDERGOING HEMODIALYSIS). However, in older adults a score of 1.0 point has been suggested as clinically meaningful (104). To our knowledge, only a previous study in maintenance HD patients (152) found a significant improvement in the SPPB score after an exercise program. The study included two groups, the exercise group performed a strengthening program for lower limbs and the control group performed a slight stretching for lower limbs. The magnitude of improvement in both groups ranged from 1.5 points in the control group to 2 points in the exercise group. Participants were older than in our study (strength group 71.1±12.6 years old, control group 66.9±13.4 years old vs our study, intradialytic 65.3±15.2 years old, home based, 61.9±12.3 years old). There is also an important difference regarding baseline SPPB scores between both studies (5 to 6 points versus 10.5 points in our study, which means between moderate and mild limitations versus minimal limitations (197)), what could result in a ceiling effect. Thus, our results suggest that SPPB score is associated with age (152). Physical impairment is related to a low SPPB score and a score less than 7 points could predict disability (195, 197).

We observed a reduction in time to stand up from a chair, walk 3 meters, go back to the chair and sit down, but only the home based group reached significance. Previous studies have evaluated the effect of an exercise program during HD (138, 170, 177, 188) or a home based program (188, 190 – 192) on functional mobility. Storer et al. (138) performed an aerobic program during 9 weeks, Bullani et al. (177) undertook a resistance program with elastic bands during 4.5 to 6 months while Anding et al. (170) studied a combined training of endurance and resistance during 12 months, obtaining significant changes in the TUG. Koh et al. (188) compared an intradialytic aerobic program with an aerobic program at home during 6 months, but they did not found significant changes in this test. They suggested that the lack of improvement in the TUG could be associated with the lack of strength exercise. Despite we included strength exercises in both groups, we only found significant improvement in the home based program. The lack of progression of sets and repetitions in the intradialytic exercise group could explain this result. Significant differences were also found in studies where a combined exercise program was performed at home for 12 months (190) and 12 weeks (191); also a Taichi home based program found significant differences after 3 months (192) in this test. We could conclude that a combined exercise program improved participants' functional mobility measured through the TUG. A change of 2.9 seconds on the TUG in CKD undergoing HD constitutes a substantial meaningful change (CHAPTER 4. TEST – RETEST RELIABILITY AND MINIMAL DETECTABLE CHANGE SCORES FOR THE SHORT PHYSICAL PERFORMANCE TEST, ONE LEG STANDING TEST AND TIMED UP AND GO IN PEOPLE UNDERGOING HEMODIALYSIS). The improvement of this test ranges from 0.5 to 2.6 seconds in the previous studies, while in our study the improvement was 0.3 seconds for the intradialytic group and 0.4 seconds for the home based. Therefore, we did not reach a clinically relevant improvement. A possible explanation could be the lack of specificity in the exercises performed during dialysis, the intensity was not high enough due to the maintenance of sets and repetitions, the low adherence to the home based program and the short duration of the exercise programs. Even though, we support the idea that the best training to improve functional mobility is the combination of endurance and resistance increasing intensity progressively.

We found a slight improvement in the STS-10, with significant decreased time in the intradialytic group. Previous studies also evaluated lower limb with the STS – 10 in exercise during the HD (114, 115, 147, 176) and at home based programs (184) observing in all of them an improvement. We did not achieve a minimal detectable change of 8.4 seconds (118). The improvement of this test in previous studies ranges from 2.5 to 5.75 seconds (114, 115, 147, 150, 160, 184), and the improvement in our study was 3.1 (CI 95% 0.2 – 6.0) and 1.5 (CI 95% -1.2 – 4.2) seconds for the intradilaytic and home based group respectively. Comparing with the previous studies, at baseline our patients needed more time to perform the test, suggesting that our sample was more disabled. The lack of adherence to the home based group has possibly affected negatively the final outcomes.

We found an increased walked distance in both groups in the 6MWT, though a significant change was achieved only in the intradialytic group (25.5 m; CI 95% 48.1 – 2.8m), as shown in previous studies (144, 169, 174). Da Silva et al. (169) found significant improvement in the 6 MWT ($p<0.001$) after a combined exercise intervention of aerobic plus strength of upper and lower limbs during 16 months. Orcy et al. (144) did a comparison of resistance vs aerobic plus resistance exercise during 10 weeks, and they only found significant changes in the 6 MWT in the combined group ($p=0.004$). The 6MWT also had significant changes ($p = 0.05$) in the study from Oliveros et al. (174) after 16 weeks of combined exercise (aerobic plus lower limbs exercises with elastic bands), compared with the control group. The reason why the home based program did not achieve statistical significance could be because of the intensity or the volume of the walking. Participants were asked to walk at least 3 times per week at an intensity of normal speed. Furthermore, it could be related to the lack of motivation to increase the intensity or the time to walk during the intervention. Another reason could be the low adherence. Whereas intradialytic exercises participants were provided with feedback for the cycle ergometer and motivated by the physical therapist and the others professionals that were in the unit to ensure they achieved the appropriate intensity, home based exercise participants trained with no supervision. Other home based studies neither found significant improvement, the difference with our study is that they worked only the aerobic capacity (185, 188). However, other home based studies obtained a significant improvement (186, 190). These studies used a pedometer for the walking training. The pedometer could give feedback to the patients and could work as a motivation factor.

Future studies on home based programs should test if by increasing supervision higher improvements are achieved.

Effectiveness of the interventions according to the physical activity level

The outcomes of the present study regarding the HAP indicate that a four-month exercise program increases the activity level in patients with CKD. We observed a significant increase of the adjusted activity score (AAS) over time (difference for all participants 7.6; CI 95% 1.9-13.4). The intradialytic exercise group increased their physical activity level, since they moved from impaired activity (HAP AAS pre=44, minimum -38 – maximum 80 points) to moderately active (HAP AAS post = 51, minimum -13 – maximum 89 points) according the HAP, while this change was not seen in the home based group. A previous study did not find significant differences after 12 weeks of resistance training vs nandrolone group in the AAS (143). The exercise group only performed resistance training during 12 weeks while the nandrolone or placebo group were administered weekly an intramuscular injection. A possible reason to explain why we obtained an improvement in the AAS could be that the combined exercise for a longer of time (16 weeks) had a higher impact on daily physical activity of participants.

Physical activity measured by the PASE significantly increased in both groups according to the within group analysis. To increase physical activity level in CKD patients in maintenance hemodialysis is important. It is well-known that the main cause of death in this cohort is the cardiovascular disease, and the number of cardiovascular problems increase in inactive population. Previous studies reported that mortality risk among HD patients who regularly exercised was, approximately, 30% lower than patients who did not exercise regularly (123, 148), while death rate for inactive people increased in 40% compared with active patients (125).

It is important to increase physical activity level in CKD patients in maintenance hemodialysis. It is well-known that the main cause of death in this cohort is the cardiovascular disease, increasing the number of cardiovascular problems when the subjects are more inactive. Some previous studies reported that mortality risk among HD patient who regularly exercised was, approximately, 30% lower than patient who did not exercise regularly (123, 148), while death rate for inactive people increased in 40% compared with active patients (125). It has been demonstrated that exercise practice could reduce cardiovascular problems. Exercise decreases hypertension and can be accompanied by a reduction in antihypertensive medications. Exercise also improves arterial stiffness, increases aerobic capacity (increase VO2 peak), increases concentrations of hemoglobin and hematocrit levels and improves lipid metabolism, reporting a reduction of plasma glucose and insulin concentration, improves plasma triglycerides and increases HDL cholesterol levels. Exercise also decreases glucose levels in blood and increases insulin sensitivity in the skeletal muscle (19, 35, 88,137, 138, 142, 143, 147, 146, 150, 155 – 166).

Physical deterioration is associated with low physical activity among HD patients, which results in a restriction, difficulty, limitation or unable in the ability to perform basic actions in daily life which could provoke disability or bedridden (126, 128, 190), associated with a significant muscle atrophy, lack of energy, fatigue, accompanied by myopathy and neuropathy symptoms, provoking cramps and restless leg symptoms (35, 38, 39 126). Subjects that increase their physical activity level improve their muscle mass and aerobic capacity, extending their lifespan (132, 257, 258). Muscle mass improvement is related to risk of falls reduction, which results in lessened the number of hospitalization (205). Symptoms of restless leg are also very common in this population, but a pilot study of 4 months concluded that an aerobic exercise program reduces the symptoms of this syndrome (39). Moreover, a combined exercise training in non-dialysis days increases the probability of returning to work with a long-term exercise program (35). The significant reduction of depression found in our study could be related to the increased physical activity level, although HRQoL remained unchanged.

Sedentary lifestyle is correlated with poor sleep quality in HD patients (148). It has been demonstrated that aerobic exercise in this population can improve sleep quality (231).

In summary, the improvement of physical activity level in CKD patients receiving hemodialysis could lead to many benefits. Future studies should demonstrate if the increased physical activity level is translated into greater independence in activities of daily living, and in such a case, it could be important to reduce future impairments such as disability, hospitalization or mortality.

Effectiveness of combined exercise program on health related quality of life and depression

After 4 months of exercise protocol during HD and at home, we found no significant effect either on the group x time interaction or the time effect on self-reported HRQoL, as assessed by the KDQoL – 36 in agreement with a previous study (184). Other studies used the KDQOL – SF, which has two different parts, the kidney disease-targeted areas and a health status questionnaire (SF – 36), and neither study found significant effect of exercise on the physical function subscale (141, 141, 192). However, a prior study found significant change in the KDQoL – SF (220), where only the aerobic group compared to a strength group found a significant improvement in the physical function subscale after 8 weeks of training.

Studies that evaluated HRQoL only with the Short-Form 36 (SF – 36) present also inconsistent results.

Previous studies found significant changes in the physical component subscale ($p<0.05$) after an aerobic exercise programs during dialysis (150, 185), at home (150, 185) and in non-dialysis days (259), but not in the mental composite (185) with a duration ranged from 8 weeks to 24 weeks.

With combined exercise programs during dialysis we can observe significant differences in the functional capacity ($p=0.030$), in the pain subscale ($p=0.015$) (169), in the physical component, in the life satisfaction for the SF-36 ($p<0.05$ for both subscales) and in the mental composite ($p=0.014$) (178) after an intervention ranging from 12 weeks to 16 months. Nevertheless, Oliveros et al. (174) did not found significant change in the SF-36 after 16 weeks of combined training during dialysis.

This inconsistency could be associated because the different duration of the exercise programs, the type of exercise used in the protocols, the intensity and the different characteristics of the participants in each study.

We believe that in this study we have not found significant differences in the KDQoL – 36 in any of the subscales because both groups, intradialytic and home based group, did not reach enough intensity or the type of exercise used in both protocols.

Depression appears from 13 up to 60% of patients in maintenance hemodialysis and may be a result of the increased morbidity and mortality associated with renal failure (86, 88). Some authors suggest that depression is a strong predictor of HRQoL (86, 91). Although in the present study no significant results in the mental composite using the KDQoL were found, we observed significant changes in the CES-D in the time factor ($p=0.017$) and in the intradialytic group ($p=0.006$), but not in the home based group. Previous studies measuring the depression with others questionnaires also found a significant improvement in this variable (191, 260, 261). This can be associated with the percentage of adherence, suggesting that a regular exercise and a high physical activity level have an important role in decreasing depression. As we can see in that study intradialytic group performed high number of exercise session and obtained better results in physical functioning, even that we cannot compare adherence with other studies.

Adherence in the exercises program

Heiwe and Jacobson observed in their review that supervised exercise training had fairly good adherence (rates of 58 – 100%), even decreased over time. Moreover, adherence decreased when patients were not under supervision, when they had to continue the exercise by their own (136). In our study, patients in the intradialytic group performed the 80.2% of the sessions. When they did not want to exercise, the physical therapist motivated them and most of the time they ended up exercising. In contrast, the home based participants performed only the 53% of the sessions proposed and it was very difficult to convince them to exercise on their own. The researcher implemented several strategies in order to improve adherence (CHAPTER 3. INTERVENTION) that were not totally successful, but the implication of nurses and nephrologists from the dialysis unit to identify and overcome barriers is absolutely compulsory. In our study, the fact that the physical therapist was external to the unit was a barrier previously described (180). Patients are more confident with nurses and nephrologists since they are with them most of the time during their treatment. Future studies should check if having greater support from the health professionals from the unit results in higher adherence rates.

Participants and clinical researchers described a range of barriers to implement the exercise programs. Primary barriers for patients in our study were lack of previous knowledge about safety and benefits in exercise programs, fear of injuries during exercise, fatigue or symptoms of weakness, and lack of interest or motivation. All them have been described in previous studies (179, 180, 182, 183). From the perspective of health professionals, the barriers that we reported were that they were not trained to encourage patients to exercise, lack of professionals (such as the physical therapist) to supervise exercise programs or to help patients to exercise, limited exercise equipment in clinical setting, and lack of financial support. These barriers have also been previously described (181, 182).

Some of these barriers justify the home based exercise implementation, as has been previously recommended, to achieve broader applicability of exercise programs (136).

STUDY LIMITATIONS

Despite findings of this study are positive for both intradialytic and home based groups, some limitations should be acknowledged. We had a high number of dropouts in both groups, and some of participants did not want to perform the exercise in the group where they were allocated, most of them preferring intradialysis exercise. Most of the participants from the home based group did not have support at home and were no supervised by a relative. The only motivation they had was at the unit when the physical therapist approached them.

Older subjects and those with high number of morbidities refused to participate, what may limit the extrapolation of results.

The level of difficulty of strength exercises in the intradialytic group could not have been high enough, although we measured the 10 RM every two weeks to ensure resistance progression.

The lack of control group in this study is another limitation. The reason why we did not have a control group was because the pre-existing evidence of the benefits of exercise.

CONCLUSION

A combined exercise of aerobic and strength after 16 weeks resulted in an improvement of the functional capacity in the intradialytic group and in the home base group. Our results suggest that the combination of aerobic and strength exercises in patients with renal failure undertaking hemodialysis was feasible and well tolerated for all the subjects.

Moreover, we found a significant change in the physical activity level, and the intradialytic group changed from impaired at baseline to moderately active after 16 weeks of combined exercise.

No significant changes in HRQoL were found, though, the intradialytic group had less depression after 16 weeks of combined exercise according to the CES-D.

Adherence was higher in the intradialytic group compared with the home base group. We believe that presence of physical therapists at the hemodialysis units increase the chances to improve physical conditioning in this cohort, and to improve adherence in the different programs. Additionally, it is necessary the participation of the different health professionals at the dialysis unit to promote exercise at home and increase the adherence in this type of modality.

Further research with larger sample is needed to determine the best approach to exercise prescription for CKD patients in hemodialysis. Health professionals from the HD unit should fight against patients' barriers to exercise. Therefore, we consider that there is a needed to modify factors from both health professionals and patients to achieve higher adherence and compliance with the exercise programs.

CHAPTER 7. GENERAL DISCUSSION

INTRODUCTION

The aims of this thesis were to assess reliability of commonly used physical functioning tests for subjects undergoing hemodialysis, to assess if there is a significant deterioration of physical functioning over a period of 6 months and to compare the effects of intradialytic exercise vs. a low cost program home based for patients with chronic kidney disease in maintenance hemodialysis.

The purpose of this final chapter is to consider and synthesize the findings from the three different study chapters in greater depth and to evaluate these findings in the context of the existing literature. Also, in this chapter, we will consider the limitations of the studies. The following table (table 1) summarizes the research questions and key findings of this thesis.

Table 7. 1 Key findings of the thesis

Research question / Study	Key findings of study
Are the Short Physical Performance Battery (SPPB), the One Leg Standing Test (OLST) and the Timed Up an Go test (TUG) reliable in CKD undergoing HD? (CHAPTER 4)	• SPPB ICC = 0.94 (CI 95% 0.91 to 0.97) • OLST ICC = 0.90 (CI 95% 0.83 to 0.94) • TUG ICC = 0.96 (CI 95% 0.94 to 0.98)
What is the minimal detectable change (MDC) for the SPPB, the OLST and the TUG in CKD undertaking HD? (CHAPTER 4)	• SPPB MDC = 1.7 points (CI 95% 1.3 to 2.1) • OLST MDC = 11.3 seconds (CI 95% 8.9 to 14.2) • TUG MDC = 2.9 seconds (CI 95% 2.2 to 3.7)
Can we observe a physical deterioration in patients receiving HD after 6 months without do any type of intervention only their daily life? (CHAPTER 5)	• SPPB (pre = 11 (1-12) points; post = 11 (1-12) points; p= 0.578) • OLST (pre = 8.2 (0-45) seconds; post = 7.3 (0-45) seconds; p= 0.379) • TUG (pre = 8.3(0-55) seconds; post = 8.2(0-28.3) seconds; p= 0.026) • STS – 10 (pre = 24.2 (0-60) seconds; post = 25.3 (0-54.34) seconds; p= 0.054) • STS – 60 (pre = 20.2 (10.1) repetitions; post = 19.9 (9.1) repetitions; p= 0.683) • HG (R hand) (pre = 25.4 (10.4) kg; post = 24.2 (10.5) kg; p=0.052) • HG (Lt hand) (pre = 21.3 (12.1) kg; post = 21.4 (11.3) kg; p=0.643) • One leg heel rise (R leg) (pre = 25 (0-25) repetitions; post = 25 (0-25) repetitions; p= 0.258) • One leg heel rise (L leg) (pre = 22 (0-25) repetitions; post = 20 (0-25) repetitions; p = 0.224

	• 6 MWT (pre = 390.9 (157.4) meters; post = 384.7 (156.9) meters; p= 0.236)
Does a 16 weeks of aerobic and strength training intervention affect in their physical functioning? (CHAPTER 6)	• SPPB (p=0.013) improvement over time, NS between groups • OLST NS over time, NS between groups, significant time per group interaction • TUG (p=0.005) improvement over time, NS between groups • STS – 10 (p=0.027) improvement over time, NS between groups • STS – 60 NS over time, NS between groups • HG (R hand) (p=0.044) improvement over time, NS between groups • HG (L hand) (p<0.001) improvement over time, NS between groups • One leg heel rise (R leg) NS over time, NS between groups • One leg heel rise (L leg) (p=0.019) improvement over time, NS between groups • 6 MWT (p=0.006) improvement over time, NS between groups
Does a 16 weeks of aerobic and strength training intervention affect in their physical activity level? (CHAPTER 6)	• HAP MAS NS over time, NS between groups • HAP AAS (p=0.011) improvement over time, NS between groups • PASE (p=0.001) improvement over time, NS between groups
Does a 16 weeks of aerobic and strength training intervention affect in their health related quality of life? (CHAPTER 6)	• KDQoL – 36 NS over time in any subscale
Does a 16 weeks of aerobic and strength training intervention affect in the level of depression? (CHAPTER 6)	• CES-D (p=0.017) improvement over time, NS between groups
Which group has high adherence in a 16	• ID 80.8%

weeks of aerobic and strength training intervention? (CHAPTER 6)	• HB 53%

AAS: Adjusted Activity Score; **CES – D:** Center for Epidemiologic Studies Depression Scale**; HAP**: Human Activity Profile; **HB:** Home based group; **HG:** Handgrip; **ID:** Intradialytic group; **L:** left; **MAS:** Maximal Activity Score; **NS:** non-significant; **OLST:** One Leg Standing Test; **PASE:** Physical Activity for Elderly; **R:** Right; **SPPB:** Short Physical Performance Battery; **STS:** sit to stand; **TUG:** Timed Up and Go

DISCUSSION OF KEY FINDINGS

Table 1 summarizes the key findings in each study, in response to the research questions and aims set out in the introduction and literature review.

Reliability of different physical performance tests

We can find different ways to evaluate end – stage disease patients' physical functioning. Some publications reported results of laboratory measures assessing a graded exercise test (exercise time or MET- metabolic equivalent of task-, peak oxygen consumption or others) (95). Recently, physical performance tests such as rising from a chair, stair climbing or gait speed, have become more popular. Another possibility is to use self-reported measures, such as the SF-36 (95).

A problem found with the laboratory measures was that patients with CKD usually were not able to complete the test due to muscular fatigue. Other limitations to use laboratory measures were found, such as the need for specialized equipment or the high cost of the procedure (35, 99, 100).

By the other hand, physical functioning can be easily measured using different physical performance tests to assess limitation found in activities of daily living. Some of the advantages are that they are easy to use, do not need high cost equipment, do not need a long time to perform them, are reproducible and patients do not suffer burden (95). Physical performance tests have been used to determine the effectiveness of different interventions in other cohorts such as dwelling older adults (102 – 106), Alzheimer disease (112), Parkinson disease (111) or heart failure (110). It is important that testing procedures are applied comprehensively and accurately in order to interpret testing results (262). There is a need to identify a set of physical function outcomes that could be relevant for patients undergoing HD and that could be assessed in the patients' treatment routine.

Segura-Ortí & Martínez-Olmos (118) evaluated the relative and absolute reliability of Sit to Stand 10 and 60 (STS 10/60), the handgrip strength, the 6 minutes walking test (6MWT) and the one heel rise test. Despite literature in elderly population reported information regarding the Short Physical Performance Battery (SPPB), the one leg standing test (OLST) and the Timed Up and Go test (TUG), no data regarding relative and absolute reliability of these tests was found in end stage renal disease patients undergoing hemodialysis. This was one of the aims of this doctoral thesis.

Our findings demonstrated that the test-retest reliability of the clinical tests was excellent, since all values were equal or above 0.90 (237). The SPPB, the OLST and the TUG are widely used performance tests probably due to their simplicity and low cost.

The SPPB is a test that measures lower extremity function using tasks that mimic daily activities and it has been found to be useful to predict outcomes such as falls, institutionalization and death in elderly population (195). This test has been used in HD patients (152, 263), but, to our knowledge, no previous studies have reported the absolute and relative reliability in CKD subjects undertaking HD. According to our results, the SPPB has an excellent test-retest reliability (ICC = 0.94; 95% CI = 0.91 – 0.97). This results are consistent with other population. In a dwelling older population (n = 487 with mean age 74.1 ± 5.7 years old), the ICC was 0.82 (102), and for older women (n= 1002 with an average age of 78.3 ± 0.3 years old) the ICC was 0.88 – 0.92 (103). Studenski et al. (102) performed the test within 1 week, as in this study, but the place where the SPPB was measured was different: the first week they assessed the SPPB during outpatient clinic visit and the second one during in a comprehensive home visit. In our study, all measures were in the same place within 1 to 2 weeks. Given that our ICC is high, we could consider the SPPB as a good physical performance measure to use in CKD patients on hemodialysis to identify loss of mobility. Future longitudinal studies should clarify if we could predict difficulties in activities of daily life as previous studies have reported in elderly and in older hospitalized patients (103, 196).

The OLST has been shown to be a good predictor of falls (234), and has been used in different cohorts. A previous studies reported the ICCs of this test are in elderly populations ICC=0.60 (105) and ICC= 0.86 (108), hip fracture (107) ICC for affected leg = 0.75 and ICC for the non-affected leg = 0.83), and for patients with lower limb amputation (109) (ICC=0.87), lower values than the ones obtained in our sample (ICC=0.90). By the other hand, in healthy military health care beneficiaries aged 18 and older, an ICC of 0.994 on a subgroup of 50 participants was reported (238).

There are many differences in the literature to perform this test and, surprisingly, there is non-consensus regarding execution. For example, some studies used as maximum time 10 seconds (238, 239), others 30 seconds (105 107, 240), 45 seconds (199, 238) or 60 seconds (108, 109, 241). The reason why we used 45 seconds as maximum time is because, Briggs et al 1989 (200) felt that a limit of 45 seconds would result in normal distribution of times (199, 200). Another factor that varies in the procedure is the number of trials to achieve the maximum time; while some studies do not report them, trials reported in the literature range between 3 (238, 241) and 5 (108, 109). Some authors use the average of the trials (108, 238) while others use the longest time of the trials for statistical analysis (109, 200, 241). Our sample had 3 trials to achieve the longest time possible and the best mark was used for data analysis. We followed Hurvitz et al. (199) procedure based on Briggs et al. (200), who suggested that three trials appear to provide a good indication of balance capabilities since they observed that the best trial results were found among the first three trials of the test. Other differences between studies are reported in the way to execute the OLST. In our study participants were allowed to have eyes open as in the studies from Kristensen et al. (109), Springer et al. (238), Giorgetti et al. (240) and Chomiack et al. (241); they were able to wear shoes on, to choose the leg they preferred for the test, and to move their arms to maintain balance (199). The number of participants, so as their age could also influence results. We included more participants than previous studies (n=62) and the age ranged from 21 to 90 years old, mean age 61.4 ± 16.4, being a relatively young sample compared to others studies. Future studies should report if this procedure is useful to predict falls in this cohort.

The TUG, is a very common test to assess functional mobility. It has been described as valid, and relative reliability values are reported in different population, such as elderly (ICC=0.99) (201) (ICC = 0.98) (204), chronic heart failure (ICC=0.93) (110), Parkinson disease (ICC= 0.80) (111) and Alzheimer disease (ICC = 0.985-0.988) (112) Our results suggest that relative reliability of this test for patients undergoing hemodialysis is excellent (ICC=0.96), and therefore it seems that this is an appropriate test to report physical function of this cohort.

People suffering from end-stage renal disease that is in a renal replacement therapy such as hemodialysis are described as sedentary with high comorbidity and high risk of mortality (94, 120). Our sample was older than 60 years old (mean age 61.7 ± 16.4 years, age range 21 to 90 years) and the Charlson index for comorbidity was 6.7 ± 2.4. We could assume that this cohort presented high variability in their health status, but surprisingly, our ICC results are higher compared with other cohorts, demonstrating that test-retest reliability (relative reliability) for these three clinical tests (SPPB, OLST and TUG) was excellent. A possible explanation could be that volunteers for this study were young and had a good health status. Another reason could be due to the protocol followed by the researchers, this was a intra rater reliability study that followed standardized instructions, at the same day of the week within 1 to 2 weeks apart. Researchers who performed the tests were trained to use standardized procedures (APPPENDIX 2. INSTRUCTIONS – SCRIPTS –).

Surprisingly, in the review carried out in the present thesis about functional testing, we found inconsistencies between testing protocols and variety of tests across published studies, as we can observe in the OLST test. These factors could lead to report inappropriate results and make comparison between studies outcomes difficult. The testing instructions (APPPENDIX 2. INSTRUCTIONS – SCRIPTS –) were the result of a consensus achieved between different research teams at every center where the study was undertaken (Valencia and Terrassa). We believe it is very important that both researchers and clinicians assess physical functioning with the same tools using standardized instructions.

Minimal detectable change

Although test-retest reliability in patients with chronic kidney disease undergoing hemodialysis was excellent, there was still a substantial degree of variability in performance for individual participants from one test session to the next.

The minimal detectable change (MDC_{90}) is a measure of sensitivity to change and is useful for interpreting change scores in individual patients (112, 118, 264, 265).

The MDC from for the SPPB, the OLST and the TUG in CKD have been studied previously in other populations such as, elderly (104, 105, 108, 195), hip fracture (107) and lower amputation (109), or Alzheimer disease (112). Nevertheless, to our knowledge this is the first study to calculate the MDC of these tests in patients with CKD undergoing hemodialysis.

In the present study the SPPB reported a MDC_{90} of 1.7 points, whereas in elderly population a 1-point change led to meaningful differences in the risk for future mortality and incident disability (195). In another study with older adults, with a big and old-age sample (n= 482, mean age 74.1 ± 5.7 years old) a SEM of 1.42 points was reported (104), while we obtained a SEM of 0.72 points. The time frame was wider than in our study, since they evaluated subjects at the participant's house every three months for the first year and every 6 months for the second year. In our study all the measurement conditions were strictly replicated, but patients in maintenance hemodialysis present wide variation in the physiological and clinical status, which can provide heterogeneity in the results.

For the OLST we found a MDC_{90} of 11.3 seconds. In a community of dwelling people the MDC_{95} was 24.1 seconds (108), which could be explained by the high SD found in the study sample (20.4 seconds) (242). In patients with lower limb amputation the MDC_{95} was 2.74 seconds (109). The difference also could be related to the evaluation procedure. In the current study we performed 3 trials with a maximum time of 45 seconds, while other studies performed 5 trials with a maximum time of 60 seconds (108, 109). We chose 3 trials instead of 5 because in order to obtain better marks in the first trials, to have less variability, and to avoid fatigability in lower muscles to achieve the longest time possible (200).

The MDC_{90} for the TUG in chronic kidney disease undergoing HD was 2.9 seconds. In a cohort with Parkinson disease the MDC_{95} was 3.5 seconds (111) (similar to our results if we calculate MDC_{90}) and in another sample with Alzheimer Disease the MDC_{90} was 4.09 seconds (112). The high MDC found in Alzheimer Disease could be explained by the high SD reported (mild moderate Alzheimer disease TUG = 19.95 ± 9.81 seconds and moderately severe to severe Alzheimer disease TUG = 28.01 ± 17.49). Patients with higher level of dementia will have higher variability, and will need more time to perform the test compared to less affected subjects. The higher variability results in higher MDC. Another difference between studies was the number of trials performed. In Huang et al 2011 (111) they only measured the TUG once to avoid fatigue, but they concluded that more trials would increase the stability of the measurement and would reduce the MDC. In patients with Alzheimer disease subjects performed 2 trials (112), while in our study they performed 3 trials. So, it seems that more than one trial increases the stability of the test, and as a result the MDC decreases.

In general, MDC_{90} of 1.7 points for the SPPB, MDC_{90} of 11.3 seconds in the OLST and MDC_{90} of 2.9 seconds in the TUG indicate that results of these three tests of 90% of subjects with CKD in hemodialysis will vary by less than 1.7 points in the SPPB, 11.3 seconds in the OLST and 2.9 seconds in the TUG. This implies that a change greater than these values are necessary in an individual patient in order to be 90% certain that the change is not due to inter trial variability.

In the clinical field, researchers and clinician should use the MDC values to determine whether a true change in the test has occurred in CKD patients in maintenance HD and to determine the amount of change that is associated with worse prognosis.

Physical deterioration after 6 months of observation

To our knowledge, this is the first study that quantifies functional decline in subjects undergoing hemodialysis over 6 months. We found that only the TUG test showed a significant decline, but it was far to reach clinical significance (0.1 seconds versus 2.9 seconds to be clinically relevant).

Renal failure progression is related to a reduction of functional capacity that worsens when hemodialysis begins. One year after the starting of dialysis this functional decline increases (83, 266, 267). Additionally, subjects on HD have impaired health related quality of life (95, 135, 193, 268, 269). Old age, malnutrition, anemia, chronic inflammation, alterations in bone mineral metabolism, cardiovascular comorbidity and altered urea metabolism could be some of the many factors that contribute to the deterioration found in this cohort, and progressively result in muscle weakness and loss of function (16, 36, 43, 148, 270). Patients undertaking hemodialysis have loss of muscle mass (atrophy, above all the fibers type II), decreased ability to generate force per unit mass or specific strength (myopathy) and have a reduction in the capacity of the central nervous system to activate otherwise normal motor unit, or a combination of all (36, 38). The presence of these symptoms results in difficulty or inability to perform certain activities of daily living such as bathing or dressing, leading to disability (126, 128, 190, 249). The decline of physical capacity worsens as time in HD increases (82, 83 119, 121 – 123).

The progressive deterioration found in chronic kidney disease is also associated with reduction in physical activity, associated with a sedentary lifestyle (82, 94). The physical activity level decreased at a rate of 3.4% per month during an observation period of one year (83, 267). Physical inactivity could lead to impaired mobility and reduced physical performance, resulting in disability (126), fracture, falls, hospitalization and mortality (119 – 124, 190).

Additionally, patients undertaking HD have imposed immobilization due to their treatment (a total of 9-16 hours per week), plus the time that patients need to recover after the treatment. This immobilization results in glucose intolerance, reduced total energy expenditure, loss of muscle protein, and loss of muscle bone and reduction of peak oxygen consumption among other complications (126). This inactivity, that is already present in early stages of renal failure and worsens along time, results in functioning deterioration and disability (82, 83, 119, 121 – 123).

Nevertheless, the rhythm at which functional decline occurs in subjects undergoing hemodialysis is unknown. This is the reason why this study aimed at quantifying the physical functioning decline over 6 months. We measured lower extremity function since it has been shown to strongly predict disability, hospitalization and mortality in older adults (195, 197).

According to our results regarding TUG, our sample are described as to be low risk of falls (201, 205) because they obtained a score < 20 seconds. However, previous researches described that 47% of CKD patients have at least one fall over one year of follow - up (205).

The lower limbs strength was indirectly measured through the STS – 10. We did not find significant differences in the time needed to stand up and sit 10 times as fast as possible at baseline versus 6 months later (pre = 24.2 minimum = 0, maximum = 60 seconds; post = 25.3, minimum 0, maximum = 54.3 seconds; p= 0.054). A previous study that reported STS-5 in hemodialysis patients results after an observation period of 16 months (n= 27 patients, mean age 61.3 ± 9.0 years old) found non-significant changes (pre 12.4±0.8 seconds; post 13.6±0.9, p = 0.21) (250). Similarly, the decreased number of repetitions achieved in the STS-60 did not reach significance (pre= 20.2 ± 10.1 repetitions; post = 19.9 ± 9.1 repetitions p = 0.68). Koufaki et al. (172), included a control group that was observed, measured at baseline and after 3 months (subjects were instructed to maintain their usual level of physical activity), and results (STS-5 pre= 12.8±4.4; post = 12.7±4.8; STS-60 pre= 23.7±6.8; post= 24.1±7.2) neither showed differences.

We observed a non-significant deterioration on 6MWT results. Bulckaen et al. (186) (n= 18) followed their sample for 12 months without doing any exercise and they did not found significant differences in the 6MWT, even that the distance walked decreased in the total sample (baseline 426±139 and 434±124 meters; after 12 months 386±152 and 410±75 meters, respectively). The control group of several studies (164) did not reach significant differences in the 6 MWT after 12 weeks. On the other hand, other studies (174) found a significant reduction in the meters walked after 16 weeks. Also, Malagoni et al. (251) observed that the distance walked decreased after 6 months, but significance was achieved later in the control group (baseline 275 ± 69 meters, after 6 months 271±76 meters, after 19±3 months 204±137 meters).

We did not find significant changes in the handgrip strength, in either right (p=0.052) or left hand (p=0.643), after 6 months of observation. This result is in agreement with previous research that observed subjects for 6 months (pre = 34.1 ± 10.4 kg, post 6 months = 33.0 ± 11.9 kg) and 12 months (post 12 months = 32.3 ± 11.4 kg) (252), or 16 months (Right hand pre = 22.3 ± 2.4 kg, post 16 months = 23.9 ± 2.0 kg; Left hand pre = 20.2 ± 2.0 kg, post 6 months = 20.2 ± 2.0 kg) (250). Another study found a slight increase in the grip strength after 12 weeks (pre = 26.8 ± 8.8, post = 28.6 ± 9.0 kg) (176).

The SPPB and the one heel rise for right land left leg neither improved nor worsened. A previous study (152), observed a control group, that did only stretching exercise with light resistance, for 48 sessions (2 times per week), and the percentage of change was 0.2 (38.4) in the SPPB score (pre = 6.0 ± 7.0; post = 6.5 ± 4.5 points). To our knowledge no other studies have been used the one heel rise and we cannot compare our results.

These results call attention because literature reports that patients undergoing HD suffer from upper and lower limb muscles weakness (36, 38). The reasons why we have not observed a physical function decline could be related to wide age range of our sample, being the young participant 21 years old and the oldest 90 years old. We could guess that young subjects have better physical condition and are more active than elderly. Moreover, our sample could not represent the real population receiving HD since dialysis population include 22% oldest than 64 years, 40% oldest than 80 years and only 3.3% between 40 and 64 years old (4, 6).

We believe that physical functioning and physical activity level should be routinely assessed at the hemodialysis units, something that is uncommon in most of the units. This information could help to detect those subjects at risk of decreasing their physical function and physical activity at a level that affects activities of daily living, and to implement interventions to reverse this situation. Thus, it could reduce the comorbidity, the risk of hospitalization and the mortality risk.

It could be argued that 6 months is not a period long enough to modify factors that result in significant loss of physical functioning. Thus, future studies should clarify if after longer periods (12 months and above), physical functioning and physical activity significantly decreases. It would be also interesting to assess inflammatory markers, and to quantify the number of falls or to register how the deterioration affects their activities of daily living.

Effectiveness of 16 weeks combined exercise program on physical function

We found a significant improvement for all participants in most of the physical functioning tests (SPPB, TUG, STS-10, bilateral handgrip strength, left one leg standing test and the 6 MWT) which means that a combined exercise program in CKD patients undergoing hemodialysis is effective to enhance physical functioning. Additionally, all participants improved the physical activity level (HAP AAS and PASE results) and depression (CES – D), but no effect was found on HRQoL. The within group analysis showed that most of the variables improved significantly only in the intradialytic exercise group (OLST, STS-10, handgrip, 6MWT, PASE, CES – D), while only the SPPB, TUG and PASE results improved significantly over time in the home based group. Only a significant group per time interaction was found on the OLST.

Previous studies concluded that exercise interventions result in functional capacity, health related quality of life and psychological improvement of this cohort (135, 136, 271). Most of these studies focused predominantly on aerobic physical exercise during HD sessions, although recently strengthening or endurance exercise has been also implemented (114, 137, 138, 166, 209).

Despite exercise benefits are described at the *National Kidney Foundation KDOQI guidelines of exercise training in CKD patients*, and despite the recommendations that "all dialysis patients should be counseled and regularly encouraged by nephrology and dialysis staff to increase level of physical activity" (177), this treatment is rarely implemented in the patients' care routine at the HD units. One of the reasons why exercise training is not implemented in HD units can be an economic problem. Home based programs could be a solution to implement exercise in CKD at lower costs (166).

For this reason, our purpose was to compare the effects of 16 weeks intradialytic versus home based exercise for hemodialysis patients.

Our results suggest that the combination of aerobic and strength exercises in patients with renal failure undertaking hemodialysis was feasible and well tolerated for all the subjects.

Regarding SPPB results, we found an increase of 1 point in both groups, but only the home based reached significance. Nevertheless, we analyzed STS – 5 and walking speed separately, and we found a time effect only for the STS – 5, that was significant only in the intradialysis exercise group (results not shown). The change in the total score did not achieve a clinically meaningful change set at 1.7 points (CHAPTER 4. TEST – RETEST RELIABILITY AND MINIMAL DETECTABLE CHANGE SCORES FOR THE SHORT PHYSICAL PERFORMANCE TEST, ONE LEG STANDING TEST AND TIMED UP AND GO IN PEOPLE UNDERGOING HEMODIALYSIS). However, in older adults a score of 1.0 point has been suggested as clinically meaningful (104). To our knowledge, only a previous study in maintenance HD patients (152) found a significant improvement in the SPPB score after an exercise program. The study included two groups, the exercise group performed a strength program for lower limbs and the control group performed a slight stretching for lower limbs. The magnitude of improvement in both groups ranged from 1.5 points in the control group to 2 points in the exercise group. Participants were older than in our study (strength group 71.1±12.6 years old, control group 66.9±13.4 years old vs our study, intradialytic 65.3±15.2 years old, home based, 61.9±12.3 years old). There is also an important difference regarding baseline SPPB scores between both studies (5 to 6 points versus 10.5 points in our study), what could result in a ceiling effect. Thus, our results suggest that SPPB score is associated with age (152). Physical impairment is related to a low SPPB score and a score less than 7 points could predict disability (195, 197).

We observed a reduction in time to stand up from a chair, walk 3 meters, go back to the chair and sit down, but only the home based group reached significance. Previous studies have evaluated the effect of an exercise program during HD (138, 170, 177, 188) or a home based program (188, 190 – 192) on functional mobility. Storer et al. (138) performed an aerobic program during 9 weeks, Bullani et al. (177) undertook a resistance program with elastic bands during 4.5 to 6 months while Anding et al. (170) studied a combined training of endurance and resistance during 12 months, obtaining significant changes in the TUG. Koh et al. (188) compared an intradialytic aerobic program with an aerobic program at home during 6 months, but they did not found significant changes in this test. They suggested that the lack of improvement in the TUG could be associated with the lack of strength exercise. Despite we included strength exercises in both groups, we only found significant improvement in the home based program. The lack of progression of sets and repetitions in the intradialytic exercise group could explain this result. Significant differences were also found in studies where a combined exercise program was performed at home for 12 months (190) and 12 weeks (191); also a Taichi home based program found significant differences after 3 months (192) in this test. We could conclude that a combined exercise program improved participants' functional mobility measured through the TUG. A change of 2.9 seconds on the TUG in CKD undergoing HD constitutes a substantial meaningful change (CHAPTER 4. TEST – RETEST RELIABILITY AND MINIMAL DETECTABLE CHANGE SCORES FOR THE SHORT PHYSICAL PERFORMANCE TEST, ONE LEG STANDING TEST AND TIMED UP AND GO IN PEOPLE UNDERGOING HEMODIALYSIS). The improvement of this test ranges from 0.5 to 2.6 seconds in the previous studies, while in our study the improvement was 0.3 seconds for the intradialytic group and 0.4 seconds for the home based. Therefore, we did not reach a clinically relevant improvement. A possible explanation could be the lack of specificity in the exercises performed during dialysis, the intensity was not high enough due to maintenance of sets and repetitions, the low adherence to the home based program and the short duration of the exercise programs. Even though, we support the idea that the best training to improve functional mobility is the combination of endurance and resistance increasing intensity progressively.

We found a slight improvement in the STS-10, with significant decreased time in the intradialytic group. Previous studies also evaluated lower limb with the STS-10 in exercise during the HD (114, 115, 147, 176) and at home based programs (184) observing in all of them an improvement. We did not achieve a minimal detectable change of 8.4 seconds (118). The improvement of this test in previous studies ranges from 2.5 to 5.75 seconds (114, 115, 147, 150, 160, 184), and the improvement in our study was 3.1 (CI 95% 0.2 – 6.0) and 1.5 (CI 95% -1.2 – 4.2) seconds for the intradilaytic and home based group respectively. Comparing with the previous studies, at baseline our patients needed more time to perform the test, suggesting that our sample was more disabled. The lack of adherence to the home based group has possibly affected negatively the final outcomes.

We found an increased walked distance in both groups in the 6MWT, though a significant change was achieved only in the intradialytic group (25.5 m; CI 95% 48.1 – 2.8m), as shown in previous studies (144, 169, 174). Da Silva et al. (169) found significant improvement in the 6 MWT ($p<0.001$) after a combined exercise intervention of aerobic plus strength of upper and lower limbs during 16 months. Orcy et al. (144) did a comparison of resistance vs aerobic plus resistance exercise during 10 weeks, and they only found significant changes in the 6 MWT in the combined group ($p=0.004$). The 6MWT also had significant changes ($p = 0.05$) in the study from Oliveros et al. (174) after 16 weeks of combined exercise (aerobic plus lower limbs exercises with elastic bands), compared with the control group. The reason why the home based program did not achieve statistical significance could be because of the intensity or the volume of the walking. Participants were asked to walk at least 3 times per week at an intensity of normal speed. Furthermore, it could be related to the lack of motivation to increase the intensity or the time to walk during the intervention. Another reason could be the low adherence. Whereas intradialytic exercises participants were provided with feedback for the cycle ergometer and motivated by the physical therapist and the others professionals that were in the unit to ensure they achieved the appropriate intensity, home based exercise participants trained with no supervision. Other home based studies neither found significant improvement, the difference with our study is that they worked only the aerobic capacity (185, 188). However, other home based studies obtained a significant improvement (186, 190). These studies used a pedometer to the walking training. The pedometer could give feedback to the patients and could work as a motivation factor. Future studies on home based programs should test if by increasing supervision higher improvements are achieved.

Effectiveness of 16 weeks combined exercise program on physical activity level

The intradialytic exercise group increased their physical activity level, since they moved from impaired activity (HAP AAS pre=44, minimum -38 – maximum 80 points) to moderately active (HAP AAS post = 51, minimum 15 – maximum 89 points) according the HAP, while this change was not seen in the home based group.

Physical activity measured by the PASE significantly increased in both groups according to the within group analysis. To increase physical activity level in CKD patients in maintenance hemodialysis is important. It is well-known that the main cause of death in this cohort is the cardiovascular disease, and the number of cardiovascular problems increase in inactive population. Previous studies reported that mortality risk among HD patients who regularly exercised was, approximately, 30% lower than patients who did not exercise regularly (123, 148), while death rate for inactive people increased in 40% compared with active patients (125). The significant reduction of depression found in our study could be related to the increased physical activity level, although HRQoL remained unchanged.

Physical deterioration is associated with low physical activity among HD patients, which results in a restriction, difficulty, limitation or unable in the ability to perform basic actions in daily life which could provoke disability or bedridden (126, 128, 190), associated with a significant muscle atrophy, lack of energy, fatigue, accompanied by myopathy and neuropathy symptoms, provoking cramps and restless leg symptoms (35, 38, 39, 126). Subjects that increase their physical activity level improve their muscle mass and aerobic capacity, extending their lifespan (132, 257, 258). Muscle mass improvement is related to risk of falls reduction, which results in lessened the number of hospitalization (205). Symptoms of restless leg are also very common in this population, but a pilot study of 4 months concluded that an aerobic exercise program reduces the symptoms of this syndrome (39).

It has been demonstrated that exercise practice could reduce cardiovascular problems. Exercise decreases hypertension and can be accompanied by a reduction in antihypertensive medications (156). Exercise also improves arterial stiffness (157), increases aerobic capacity (increase VO2 peak) (155, 158, 162, 165), increases concentrations of hemoglobin and hematocrit levels and improves lipid metabolism, reporting a reduction of plasma glucose and insulin concentration, improves plasma triglycerides and increases HDL cholesterol levels. Exercise also decreases glucose levels in blood and increases insulin sensitivity in the skeletal muscle (158, 161). Sedentary lifestyle is correlated with poor sleep quality in HD patients (148). It has been demonstrated that aerobic exercise in this population can improve sleep quality (231). Moreover, a combined exercise training in non-dialysis days increases the probability of returning to work with a long-term exercise program (88).

Summary, the improvement of physical activity level in CKD patients receiving hemodialysis could lead to many benefits. Future studies should demonstrate if the increased physical activity level is translated into greater independence in activities of daily living, and in such a case, it could be important to reduce future impairments such as disability, hospitalization or mortality.

Effectiveness of combined exercise program on health related quality of life and depression

We found no significant effect either on the group per time interaction or the time effect on self-reported HRQoL as assessed by the KDQoL – 36 in agreement with a previous study (184). Other studies used the KDQoL – SF, which has two different parts, the kidney disease-targeted areas and a health status questionnaire (SF – 36), and neither study found significant effect of exercise on the physical functioning subscale (141, 176, 192). However, a prior study found significant change in the KDQoL – SF (145), where only the aerobic group compared to a strength group significantly improved on the physical functioning subscale after 8 weeks of training.

Studies that evaluated HRQoL only with the Short – Form 36 (SF – 36) present also inconsistent results.

Several studies found significant changes in the physical component subscale after an aerobic exercise program during dialysis (185, 150), at home (150, 185) or in non-dialysis days (259), but not in the mental composite (185). The length of the programs ranged from 8 to 24 weeks.

Combined exercise programs during dialysis resulted in significant improvement in the pain subscale (169), physical component, life satisfaction for the SF-36 and mental composite (178) after interventions ranging from 12 weeks to 16 months. Nevertheless, Oliveros et al 2011 (174) did not found significant change in the SF – 36 after 16 weeks of combined training during dialysis.

This inconsistency could be due to the different duration of the exercise programs, the type of exercise used in the protocols, the intensity and the different characteristics of the participants in each study.

A possible explanation to explain why we have not found significant differences in the KDQoL – 36 in any of the subscales could be because none of the groups reached enough intensity or the low adherence in the home based group. Also the low adherence in this type of interventions can affect in the HRQoL results.

Although in the present study no significant results in the mental composite using the KDQoL were found, we observed significant changes in the CES – D in the time factor, that was observed only in the intradialytic group according to the within group analysis. Depression appears from 13 up to 60% of patients in maintenance hemodialysis and may be a result of the increased morbidity and mortality associated with renal failure (86, 88). Some authors suggest that depression is a strong predictor of HRQoL (86, 91).

Previous studies measuring the depression with others questionnaires also found a significant improvement in this variable (191, 260, 261). This can be associated with the percentage of adherence, suggesting that regular exercise and high physical activity have an important role in decreasing depression. In our study intradialytic group undertook higher number of exercise sessions and obtained better results in the physical functioning, compared to the home based exercise group.

Adherence in the exercise program

Heiwe and Jacobson observed in their review that supervised exercise training had fairly good adherence (rates of 58 – 100%), even decreased over time. Moreover, adherence decreased when patients were not under supervision, when they had to continue the exercise by their own (136). In our study, patients in the intradialytic group performed the 80.2% of the sessions. When they did not want to exercise, the physical therapist motivated them and most of the time they ended up exercising. In contrast, the home based participants performed only the 53% of the session proposed and it was very difficult to convince them to the exercise on their own. The researcher implemented several strategies in order to improve adherence (CHAPTER 3. INTERVENTION) that were not totally successful, but the implication of nurses and nephrologists from the dialysis unit to identify and overcome barriers is absolutely compulsory. In our study, the fact that the physical therapist was external to the unit was a barrier previously described (180). Patients are more confident with nurses and nephrologists since they are with them most of the time during their treatment. Future studies should check if having greater support from the health professionals from the unit results in higher adherence rates.

Participants and clinical researchers described a range of barriers to implement the exercise programs. Primary barriers for patients in our study were lack of previous knowledge about safety and benefits in exercise programs, fear of injuries during exercise, fatigue or symptoms of weakness, and lack of interest or motivation. All them have been described in previous studies (179, 180, 182, 183). From the perspective of health professionals, the barriers that we reported were that they were not trained to encourage patients to exercise, lack of professionals (such as the physical therapist) to supervise exercise programs or to help patients to exercise, limited exercise equipment in clinical setting, and lack of financial support. These barriers have also been previously described (181, 182).

Some of these barriers justify the home based exercise implementation, as has been previously recommended, to achieve broader applicability of exercise programs (136).

LIMITATIONS OF THIS THESIS

Results from the different studies should be interpreted with caution since the sample size is small and participants were heterogeneous regarding age range, medical history, and physical activity background.

Since we found a high variety in the protocol for physical functioning measures, it is possible that the standardized protocol that we developed as a consensus between research teams is not the same as previous studies, and so comparison is limited.

We had recruitment limitations, since many participants did not consent to complete the tests or to perform the intervention. Our sample was relatively young and therefore, it did not fully represent elderly subjects commonly found in dialysis units.

Another limitation was the time constrains that we had to assess patients, only 30 minutes prior to the dialysis session. Sometimes patients did not arrive on time to perform the test or they were late and they had to start the treatment. Other times, patients were not motivated to perform testing. This fact could also influence our results.

In perspective, we think that the 6 months' period we waited to re test patients in the observational study was not long enough.

Despite the proven benefits of exercise in this cohort, the implementation of exercise programs in HD units is not an easy task. We found a lack of human and structural resources. Additionally, the high comorbidity and low motivation of patients or health professionals are some of the many barriers to exercise implementation as part of the routine care of renal patients.

Regarding the intervention, the adherence rate to the home based exercise was low. Some patients did not want to exercise at home because of time constraints and they did not have enough support to help them or to motivate them to exercise. Some patients were angry at the physical therapist because they wanted to perform the exercise during the dialysis as other partners and they did not understand allocation was randomized, even though the procedure was explained and they signed the written informed consent at the beginning of the study. The high number of dropouts in both groups is another limitation.

It is worth it to highlight that our intervention was safe and not adverse effects occurred, in spite of the different complications that CKD patients suffered due to the disease and the treatment.

The follow-up after the intervention was limited, despite it was similar to the majority of previously published work.

The lack of control group in the intervention study means that results cannot be compared to the ongoing disease with usual care.

FUTURE RESEARCHERS

It is recommended to have bigger sample that includes elderly patients.

It is important that in both research and clinical fields health professionals use standardized methodological procedures to assess physical function.

Further research should examine physical deterioration over a long-term period. It could also be interesting to correlate physical function and risk of falls, reporting the number of falls that patients have along a period of time (more than 6 months) and correlate between variables. Also it could be interested quantify the muscle deterioration and do a correlation between the physical functional measures and the functional dependence and the effects in basic and instrumental activities of daily living.

Regarding exercise intervention studies that include home based programs, future studies should be supported by health care professionals from the unit in order to achieve higher participation and to increase adherence. Moreover, it would be helpful to add education sessions at the unit or at their homes to teach them the exercise and to solve all the doubts that may appear. It could also be useful to provide pedometers to increase exercise intensity and motivation.

CHAPTER 8. CONCLUSIONS

1. The Short Physical Performance Battery, the One Leg Standing Test and the Timed Up and Go test show excellent test-retest reliability (≥0.90) in people undergoing hemodialysis. The MDC_{90}values for each test provide clinicians with thresholds for identifying changes beyond those expected from individual variability.

2. Patients on hemodialysis do no show a significant impairment in functional capacity, strength, physical activity level and health related quality of life after six months.

3. A combined exercise program after 16 weeks resulted in an improvement of the functional capacity in both groups the intradialytic and the home base.

4. A combined exercise program resulted in a significant increase in the physical activity level. The intradialytic group changed from impaired at baseline to moderately active after 16 weeks of combined exercise.

5. A combined exercise program did not change significantly HRQoL. The program resulted in less depression in the intradialytic exercise group according to the CES-D.

6. Adherence was higher in the intradialytic group compared to the home base group.

CHAPTER 9. APPENDICES

APPENDIX 1. WRITTEN INFORMED CONSENT

CONSENTIMIENTO INFORMADO

Este es un estudio de investigación en fisioterapia. Eva Segura, Fisioterapeuta y profesora en la Universidad CEU Cardenal Herrera, Lucía Ortega Pérez de Villar, Fisioterapeuta y profesora en la Universidad CEU Cardenal Herrera, u otro personal le explicará en que consiste el estudio.

Los estudios de investigación en fisioterapia incluyen únicamente a personas que voluntariamente deciden participar en ellos. Tome su tiempo para decidir si quiere o no participar. Puede comentar su decisión con familiares, amigos o con los profesionales de la salud que le atienden de forma habitual. Cualquier pregunta sobre el estudio se la aclararemos cualquiera de los que formamos el equipo de investigación en este estudio.

¿Por qué se realiza este estudio?

Este proyecto de investigación consiste en estudiar la capacidad funcional de los pacientes con insuficiencia renal crónica en hemodiálisis en un periodo de 6 meses y en la implantación posterior de un programa de ejercicio durante la sesión de hemodiálisis y en casa, y la valoración de los efectos del mismo

¿Qué pasa si participo en este estudio?

Si decide participar en este estudio, tendrá que realizar una serie de pruebas adaptadas a pacientes como usted previamente a la sesión de hemodiálisis. Los días de realización serán Lunes, Miércoles y Viernes o Martes, Jueves y Sábado, dependiendo del turno de hemodiálisis. Será citado 4 días antes, y la duración de las mismas es de unos 20 minutos cada una. Además, le será entregado un cuestionario que podrá completar durante la sesión de hemodiálisis con ayuda de los investigadores de este proyecto. Tras las pruebas iniciales se volverá a realizar esta valoración a los 6 meses sin haber implantado aún ninguna intervención. Después de las segundas mediciones usted será asignado a un grupo de los dos posibles y un fisioterapeuta del equipo de investigación le enseñará una serie de ejercicios que tendrá que realizar o bien durante la sesión de diálisis o bien en casa, adaptados a pacientes en hemodiálisis, y que realizará durante 4 meses. Tras este periodo se le citará para realizar de nuevo las pruebas realizadas al inicio del programa.

¿Que ocurrirá durante el estudio?

Las pruebas que va a realizar se detallan a continuación, con una duración aproximada de 20 minutos cada una. Si necesita descansar durante las mismas podrá hacerlo. Puede dejar de participar en cualquier momento del estudio si cambia de opinión.

- **Revisión de la historia clínica**: Los investigadores revisarán su historia clínica y le harán algunas preguntas para tener una idea de factores que pueden influir en la capacidad física, como la presencia de hipertensión, enfermedad cardiaca, diabetes, si es fumador, así como medicación que esté tomando. Además, los investigadores revisarán las analíticas que se le realizan periódicamente en la unidad de hemodiálisis.
- **Cuestionario KDQoL - 36**: Se le pedirá que conteste a un cuestionario. Podrá hacerlo durante la sesión de diálisis, **con la ayuda de un investigador si lo necesita**, o podrá llevárselo a casa y traerlo contestado a la próxima sesión de diálisis. Algunas de las preguntas en el cuestionario incluyen preguntas:
    - De componente física y mental
    - Síntomas y problemas relacionados con su enfermedad
    - La carga de su enfermedad renal
    - Efectos de su enfermedad renal
- **Cuestionario HAP y PASE:** son dos cuestionarios que tendrá que completar también durante la sesión de hemodiálisis con ayuda de algún investigador. Se pretende calcular el nivel de actividad que usted tiene.

- **Cuestionario CES – D**: es un cuestionario para evaluar el nivel de depresión que usted pueda tener. También lo rellenará en la unidad de diálisis con la ayuda de un investigador.
- **Pruebas físicas funcionales**
    - Equilibrio - Se le pedirá que mantenga tres posiciones durante 10 segundos cada una, o el máximo tiempo que pueda: permanecer de pie con los pies juntos pegados, permanecer de pie con los pies juntos con el talón de un pie a la altura del dedo gordo del otro pie, y permanecer de pie con el talón de un pie pegado por delante al dedo gordo del otro pie. Finalmente se le pedirá que permanezca el mayor tiempo posible, hasta un máximo de 45 segundos, sobre un solo pie (a pata coja). Un investigador estará cerca de usted para evitar cualquier caída.
    - Velocidad de la marcha - Se le pedirá que camine una distancia de 4 metros a su ritmo de andar normal. Repetirá esta prueba dos veces un investigador le cronometrará.
    - Prueba de ponerse de pie desde una silla – Comenzará sentado y se le pedirá que se levante y se siente tan rápido como pueda durante 5 ó 10 veces consecutivas, según el test que se esté realizando. El evaluador contará cuánto tiempo le cuesta. Un investigador le cronometrará. Luego repetirá el mismo ejercicio, pero levantándose y sentándose tantas veces como pueda durante un minuto, permitiéndole descansar en cualquier momento si lo necesita.
    - Prueba de equilibrio dinámico – Usted estará sentado en una silla sin reposabrazos y cuando el investigador le diga “ya” tendrá que levantarse, caminar 3 metros, girar un cono y volver a sentarse lo más rápido y seguro que pueda. Se repetirá tres veces.
    - Fuerza muscular del agarre de la mano - Se colocará sentado, con el codo doblado y apoyado en una mesa, y se le pedirá que apriete el instrumento con la máxima fuerza posible. Lo

repetirá 3 veces, con un descanso de 15 segundos entre una y otra repetición.

- Fuerza del Tríceps – Se apoyará sobre una pierna, y para mantener el equilibrio podrá ayudarse del apoyo en la pared, con los dos brazos estirados y separados del cuerpo. Sin que los brazos le ayuden a levantarse, elevará el talón colocándose de puntillas sin flexionar la rodilla, a ritmo de un aparato que le marcará con un pitido cada segundo, de forma que estará 1 segundo arriba, 1 segundo abajo. Contaremos el número de repeticiones, y si llega a 25 detendremos la prueba en ese momento.
- 6 minutos marcha – Se le pedirá que camine la máxima distancia posible durante 6 minutos, en un pasillo de 20 metros de longitud, marcado cada dos metros, y girando sin parar al final del mismo. Se le permitirá parar si lo necesita y podrá reiniciar la prueba. Al finalizar la misma se le mostrará una escala para que muestre el nivel de cansancio que le ha producido la prueba.

¿Cuánto tiempo dura este estudio?

Una vez el paciente es valorado los pacientes susceptibles de poder realizar ejercicio serán incluidos en el programa. Los pacientes serán asignados **de forma aleatoria** a uno de los dos posibles grupos: se realizará los días de hemodiálisis, tres veces por semana, durante las dos primeras horas del tratamiento o bien en casa.

Grupo de ejercicio intradiálisis (ejercicio aeróbico y de fuerza-resistencia durante la hemodiálisis) o **Grupo de ejercicio en casa** (recoge ejercicios de los aspectos medidos en las pruebas funcionales). Ambos programas tienen una duración aproximada de 4 meses.

Los pacientes que se encuentren en el grupo de ejercicio durante la hemodiálisis realizarán ejercicio suave supervisado por un fisioterapeuta, mediante una bicicleta o mediante pesas en las piernas. En ambos casos consistirá en realizar movimientos con las dos piernas, sin necesidad de mover el tronco ni los brazos con lo que la sesión de hemodiálisis tendrá lugar con toda normalidad. Este tipo de programas se vienen realizando en otros países y han demostrado ser beneficiosos para los pacientes. Sin embargo, aún es necesaria mucha investigación para clarificar todos los beneficios obtenidos a partir del ejercicio.

Aquellos que realicen el programa de ejercicio en el domicilio, realizarán ejercicios con pesas y tendrán que caminar. Se les dará apoyo en las sesiones de hemodiálisis y por contacto telefónico para favorecer el seguimiento del programa. Este tipo de programa a domicilio ha resultado tener beneficios en otras poblaciones como ancianos y población obesa.
De forma diaria y antes de realizar ningún ejercicio el fisioterapeuta, junto con el personal de enfermería y el nefrólogo de la sala, valorará la situación actual del paciente y le preguntará cómo se encuentra, de forma que evitará la realización de ejercicio en días en que el paciente se encuentre indispuesto o su estado de salud no aconseje la realización del programa debido a posibles riesgos derivados (aparición de mareo, dolor en piernas, cansancio muscular, alteraciones cardiacas).

De forma diaria y antes de realizar ningún ejercicio el fisioterapeuta, junto con el personal de enfermería y el nefrólogo de la sala, valorará la situación actual del paciente y le preguntará cómo se encuentra, de forma que evitará la realización de ejercicio en días en que el paciente se encuentre indispuesto o su estado de salud no aconseje la realización del programa debido a posibles riesgos derivados (aparición de mareo, dolor en piernas, cansancio muscular, alteraciones cardiacas).

¿Puedo dejar de participar en el estudio?
Sí, puede dejar el estudio en cualquier momento. Dígale a algún investigador que está pensando en dejar el estudio o que ha decidido dejarlo. El médico de la unidad puede indicar que deje el estudio en cualquier momento si cree que es mejor para usted o si no sigue las normas del estudio.

¿Qué efectos no deseados o riesgos puedo esperar por participar en el estudio?

Existe la posibilidad de una caída durante las pruebas funcionales de marcha o de equilibrio. Para minimizar el riesgo se le pedirá que ande a un ritmo habitual o que utilice ayudas para la marcha que normalmente utilice (bastón, andador, etc.) para que se sienta seguro. Un investigador estará cerca de usted en las pruebas de equilibrio para prevenir caídas.

Existe la posibilidad de que su piel se irrite por la colocación de pesas o de la bicicleta. Ante cualquier ligera molestia comuníquelo para prevenir estas irritaciones.

Puede haber riesgos por ahora desconocidos, que tan pronto se conozcan se le comunicarán por si quiere dejar el estudio.

¿Existen beneficios por participar en el estudio?

Este estudio pretende que usted mejore su capacidad física, lo cual se traduce en una mayor facilidad en la realización de actividades de la vida diaria como andar o subir escaleras. Este estudio ayudará a conocer mejor la capacidad física de los pacientes en hemodiálisis, a clarificar el beneficio del ejercicio y qué tipo de ejercicio es más recomendable y en general a mejorar el tratamiento de futuros pacientes que necesiten hemodiálisis.

¿Qué otras opciones tengo si no participo en el estudio?

Puede seguir recibiendo su tratamiento habitual de hemodiálisis sin participar en el estudio. Por favor, hable con su médico antes de decidir si finalmente participará en el estudio.

¿Será confidencial toda la información sobre mi salud?

Haremos todo lo posible para que su información personal y médica sea confidencial. Sin embargo, no podemos garantizar una total privacidad. Su información personal puede ser requerida por la *Ley Orgánica 15/1999, de 13 de diciembre, de Protección de Datos de Carácter Personal* y a su Reglamento de desarrollo, aprobado por Real Decreto 1720/2007, de 21 de diciembre.

Si la información se publica en jornadas, congresos o revistas científicas su nombre y otra información personal no se utilizarán.
Los organismos que pueden acceder a sus datos con motivos de investigación, calidad o análisis de datos son la Universidad CEU-Cardenal Herrera, la Clínica Virgen del Consuelo y el Hospital General Universitario de Valencia.

¿Qué costes le supone participar en el estudio?
Ninguna de las actividades de la investigación supondrá coste para usted.

¿Recibiré dinero por participar en el estudio?
Lamentablemente no disponemos de financiación que cobra ninguna partida presupuestaria para remunerar su participación.

¿Qué ocurre si me lesiono por participar en el estudio?
El personal que realice la intervención son Fisioterapeutas diplomados/graduados. Diríjase a cualquiera de ellos en caso de aparecer algún problema. También puede llamar a la investigadora principal, Eva Segura, al teléfono 961369000, Extensión 1371 o a Lucía Ortega al número de teléfono 661161547 o consultarlo con el médico de la unidad de hemodiálisis.

¿Qué derechos tengo si participo en este estudio?
Participar en este estudio es voluntario, usted elige participar o no hacerlo. Si decide participar puede abandonar el estudio en cualquier momento. Independientemente de su decisión, recibirá su tratamiento habitual en la unidad de hemodiálisis. Dejar el estudio no tendrá ninguna implicación en su tratamiento médico habitual.
Le informaremos sobre cualquier información nueva del estudio que pueda afectar a su salud o a su decisión de participar en el estudio.

¿Quién puede responder a mis dudas sobre el estudio?

Puede hablar con la investigadora principal sobre preguntas, preocupaciones o quejas que tenga sobre el estudio. Investigador principal, Eva Segura, al teléfono 961369000, Extensión 1371

CONSENTIMIENTO ESCRITO

ACUERDO EN LA PARTICIPACION EN EL ESTUDIO

Resultados de un programa de ejercicio durante la hemodiálisis y a domicilio en pacientes con Insuficiencia Renal Crónica

Yo ___________________________________ estoy de acuerdo en participar en el estudio mencionado anteriormente. Los objetivos del estudio se me han explicado y entiendo que cualquier información sobre mi persona es estrictamente confidencial.

Entiendo que si en cualquier momento decido que no deseo participar en este estudio, puedo abandonarlo. También entiendo que si abandono el estudio o si decido no participar esto no afectará a cualquier tratamiento presente o futuro que precise.

Firmado __________________________________ Fecha ____________

Teléfono __________________________________

APPENDIX 2. INSTRUCTIONS – SCRIPTS –

Instructions for the researcher: All the tests should be performed in the same order in which it appears in the document. The instructions for the researcher and the participants are developed in each test and should be given exactly are written in this script (text in ***bold and italic***).

For those researchers who are going to use these tests for the first time it is recommended that two researchers register the times to ensure the accurate measurement.

SHORT PHYSICAL PERFORMANCE BATTERY

The scripts that have been used in the SPPB are the following:

Moment to assess the test: previously the first or the second hemodialysis session of the week. Rather do it before the first hemodialysis session.

Material: stopwatches, instructions, register sheets, adhesive tape, a chair without armrest, and two cones.

Aim: To evaluate lower extremity (balance, walking speed, ability to rise from a chair)

Procedure:

1. **BALANCE TEST**

Material: stopwatch, instructions, registers sheets

The participants must be able to stand unassisted without the use of aids. The research may help the participants to get up if is necessary.

"Now let's begin the evaluation. I would now like you to try to move your body in different movements. I will first describe and show each movement to you. Then I would like you to try to do it. If you cannot do a particular movement, or if you feel it would be unsafe to try to do it, tell me and we will move on to the next one. Let me emphasize that I do not want you to try to do any exercise that you feel might be unsafe. Do you have any question before we begin?"

A. **Sid-by-side stand**

"Now I will show you the first movement (demonstrate as in the Figure 1.A)***. I want you to try to stand with your feet together, side-by-side, for about 10 seconds. You may use your arms, bend your knees or move***

your body to maintain your balance, but try not to move your feet. Try to hold this position until I tell you to stop"

Stand next to the participant to help him/her into the side-by-side position. Supply just enough support to the participant's arm to prevent loss of balance. When the participant had his/her feet together ask ***"Are you ready?".*** Then let go and begin timing as you say, ***"Ready, begin".***

Stop the stopwatch and say, ***"Stop"*** after 10 seconds or when the participant steps out of position or grabs your arm. If participant is unable to hold the position for 10 seconds, record result and go to the gait speed test.

Scoring:

- **1 point** → the participant is able to maintain this position for 10 seconds
- **0 points** → the participant is not able to maintain this position or maintain this position during less time than 10 seconds

B. Semi-Tandem Stand

"Now I will show you the second movement (demonstrate). ***Now I want you to try to stand with the side of the heel of one foot touching the big toe of the other foot for about 10 seconds. You may put either foot in front; whichever is more comfortable for you. You may use your arms, bend your knees, or move your body to maintain your balance, but try not to move your feet. Try to hold this position until I tell you to stop"***

Stand next to the participant to help him/her into the semi-tandem position. Supply just enough support to the participant's arm to prevent loss of balance. When the participant had his/her feet together ask ***"Are you ready?".*** Then let go and begin timing as you say, ***"Ready, begin".***

Stop the stopwatch and say, ***"Stop"*** after 10 seconds or when the participant steps out of position or grabs your arm. If participant is unable to hold the position for 10 seconds, record result and go to the gait speed test

Scoring:

- **1 point** → the participant is able to maintain this position for 10 seconds

- **0 points** → the participant is not able to maintain this position or maintain this position during less time than 10 seconds

C. **Tandem Stand**

" Now I will show you the third movement (demonstrate). ***Now I want you to try to stand with the heel of one foot in front of and touching the toes of the other foot for about 10 seconds. You may put either foot in front; whoever is more confortable for you. You may use your arms, bend your knees, or move your body to maintain your balance, but try not to move your feet. Try to hold this position until I tell you to stop"***

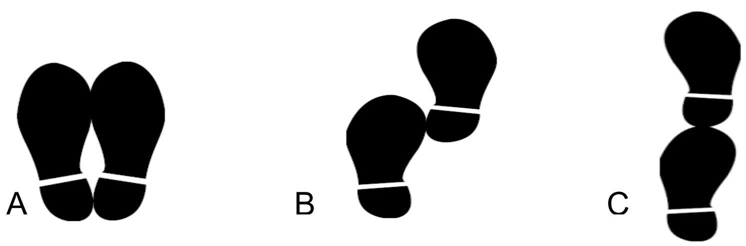
Stand next to the participant to help him/her into the tandem position. Supply just enough support to the participant's arm to prevent loss of balance. When the participant had his/her feet together ask ***"Are you ready?".*** Then let go and begin timing as you say, ***"Ready, begin".***

Stop the stopwatch and say, ***"Stop"*** after 10 seconds or when the participant steps out of position or grabs your arm. If participant is unable to hold the position for 10 seconds, record result and go to the gait speed test

Scoring:

- 2 points → the participant is able to maintain this position for 10 seconds
- **1 point** → the participant is able to maintain this position for 3 to 9.99 seconds
- **0 points** → the participant is not able to maintain this position or maintain this position during less time than 3 seconds

Figure 9. 1 Schematic illustration of the Standing Balance included in the Short Physical Performance Battery. A) Side by Side; B) Semi-Tandem Stand; C) Tandem Stand.



2. **GAIT SPEED TEST**

Material: stopwatch, instructions, registers sheets, adhesive tape separate 4 meters plus half meter per each end.

Note: Is better if the participants do not wear heel shoes. If the subject uses a walking aid but he/she can walk a short distance without the aid, may do the test without use it if he/she feels safe. If the register is considerate a bad register the research may consider repeating the test.

"Now I am going to observe how you normally walk. If you use any walking aid and you feel you need it to walk a short distance, then you may use it, but if you think you can walk a short distance without a walking aids then you may not use it.

A. **First gait Speed test**

"This is our walking course. I want you to walk to the other end of the course at your usual speed, just as if you were walking down the street to go to the store". Demonstrate the walk for the participant (Figure 2). Is better if the participant does not wear heel shoes.

"Walk all the way past the other end of the tape before you stop (we give him/her a reference two or three more meters to avoid braked)**. I will walk with you. Do you feel this would be safe?**

The participant has to be stand with both feet touching the starting line.

"When I want you to start, I will say: "Ready, begin"" When the participant acknowledges this instruction say: **"Ready, begin"**

Press the start/stop button to start the stopwatch as the participant begins walking not when the research gives the order. Walk behind and to the side of the participant but out of her/his viewable range. The evaluator has to stop the watch when the person totally transfers the line.

Stop timing when one of the participant's feet is completely across the end line or when the body transfers an imaginary plane in the arrival line, as a mirror.

B. **Second Gait Speed Test**

"Now I want you to repeat the walk. Remember to walk at your usual pace, and go all the way past the other end of the course.

The participant has to be stand with both feet touching the starting line.

“When I want you to start, I will say: “Ready, begin”” When the participant acknowledges this instruction say: **“Ready, begin”**

Press the start/stop button to start the stopwatch as the participant begins walking not when the research gives the order. Walk behind and to the side of the participant but out of her/his viewable range. The evaluator has to stop the watch when the person totally transfers the line.

Stop timing when one of the participant’s feet is completely across the end line or when the body transfers an imaginary plane in the arrival line, as a mirror.

Scoring:

- 4 points: the time required by the participant to perform the test is equal or less than 4.82 seconds
- 3 points: the participant perform the test between 4.82 and 6.20 seconds
- 2 points: the participant perform the test between 6.21 to 8.70 seconds
- 1 point: the time required by the participant is greater or equal than 8.70

Figure 9. 2 Schematic illustration for the gait speed

3. CHAIR STAND TEST

Single Chair Stand

“Let’s do the last movement test. Do you think it would be safe for you to try to stand up from a chair without using your arms? (The participant tries)

“The next test measures the strength in your legs. (Demonstrate and explain the procedure). ***First, fold your arms across your chest and sit so that your feet are on the floor; then stand up keeping your arms folded across your chest. Please stand up keeping arms folded across your chest”*** (Record result)

If participant cannot rise without using arms, say "Okay, try to stand up using your arms". This is the end of their test. Record result and go to the scoring page.

Repeated Chair Stands

"Do you think it would be safe for you to try to stand up from a chair five times without using your arms?" (Demonstrate and explain the procedure): ***"Please stand up straight as QUICKLY as you can five times, without stopping in between. After standing up each time, sit down and then stand up again. Keep your arms folded across your chest. I will be timing you with a stopwatch"***

When the participant is properly seated, say: ***"Ready? Stand"*** and begin timing.

Count out loud as the participant arises each time, up to five times. Stop if participant becomes tired or short of breath during repeated chair stands.

Stop the stopwatch when he/she has straightened up completely for the fifth time.

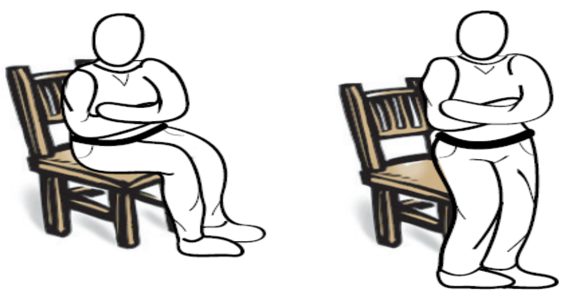
Also stop:

- If participant uses his/her arms
- After 1 minute, if participant has not completed rises
- At your discretion, if concerned for participant's safety

If the participant stops and appears to be fatigued before completing the five stands, confirm this by asking, ***"Can you continue?"***

If participant says "Yes", continue timing. If participant says "No", stop and reset the stopwatch.

Figure 9. 3 Schematic Illsutration for the sit to stand



Scoring:

- **4 points** → the participant require equal or less than 11.19 seconds to stand five times
- **3 points** → the participant require between 11.20 to 13.69 seconds to stand five times
- **2 points** → the participant require between 13.70 to 16.69 seconds to stand five times
- **1 point** → the participant require 16.70 or more to stand five times
- **0 points** → the participant require more than 60 seconds to stand five times

ONE LEG BALANCE TEST (UNIPEDAL TEST, ONE LEG STANCE TEST)

The scripts that have been used in the OLST are the following:

Moment to assess the test: previously the first or the second hemodialysis session of the week. Rather do it before the first hemodialysis session.

Material: stopwatches, instructions, register sheets

Aim: To assess the time that the subject maintains the balance in one leg stance position.

Procedure: We asked the subject to raised one leg and maintain a unipedal position, but the subject needs to be safe in that position (the subject is allowed to choose the leg they preferred for the test, and if he/she had pain or other symptom in the first leg he/she is permitted to change the limb and use the other one). If the subject request help to assume the testing position were permitted to use the researcher's arm to steady him/herself prior to starting the test. We asked the participant to maintain the balance as long as possible. The investigator will register the time that the participant maintains the balance and the foot that support the weight (the supported limb). To maintain the balance the subject is allow to move arms, the body and can make a flexion in the supported limb. The test is with eyes open and the subject wears shoes. The time ends when (1) the participant use their arms to touch the wall, or any part of the room and the investigator; (2) if the foot that is raised touched the ground; (3) used the suspender foot to support weight-bearing limb; (4) if the subject move the foot which is standing or (5) when time arrive to 45 seconds. The procedure is repeated 3 times and each time is record on the register sheet. For the data analysis we register the longest time of the 3 times obtained.

Participant instructions:

"Now I will show you the next movement (demonstrate). ***Now I want you to try to stand with one leg stance for 45 seconds, with which foot will you kick if a trough you a ball? You may try to maintain the balance with that foot; if you have pain or other symptom you can maintain the balance with the other limb. You may use your arms, bend your knee, or move your body to maintain your balance, but try not to move your supported foot. Try to hold this position until I tell you to stop"***

Stand next to the participant to help him/her into the one leg stance position. Supply just enough support to the participant's arm to prevent loss of balance. When the participant had his/her feet together ask ***"Are you ready?".*** Then let go and begin timing as you say, ***"Ready, begin".***

Stop the stopwatch and say, ***"Stop"*** after 45 seconds or when the participant steps out of position or grabs your arm.

The participant is up to do other two trials if the first does not maintain 45 seconds.

We do this way following the SPPB test model.

Results: We will record the best time in seconds from the three trials and the standing leg.

Figure 9. 4 Schematic Illustration for the one leg standing test

TIMED UP AND GO (TUG)

The scripts that have been used in the TUG are the following:

Moment to assess the test: previously the first or the second hemodialysis session of the week. Rather do it before the first hemodialysis session.

Material: stopwatches, a standardized armchair, a cone or adhesive to mark three meters, instructions and register sheets

Aim: To assess the time (in seconds) taken to stand up from a chair, walk 3 meters, turn a cone, return to the chair and sit down again. It is a valid method to assess mobility.

Procedure: The person has to be sitting correctly in a standardized armchair with the back in the backrest. The chair may be stable to avoid fall risks during the test, so the chair will be all the time touching the wall. We asked the subject to raised raise from the chair, walk three meters away from the front edge of the chair, turn the cone, walk back to the chair and sit down again in the chair. If the subject request arms to stand up or needs the usual walking aid can use them but we have to register it. The subject wear non-heel shoes if is possible. The investigator will register the time that the participant needs to complete the test as quickly and safely as possible. The procedure is repeated 3 times and each time is record on the register sheet. The first time is to become familiar with the test. For the data analysis we register the best time of the 3 times obtained.

Participant instructions:

"Now I will show you the next movement (demonstrate). ***Now I want you to rise from the chair, walk as quickly and safely as possible, turn the cone, walk back and sit down again. You may use your arms, or your usual walking aid if needed. I will record the time you need to complete this test"***

We asked the participant to perform the first trial to become familiar with the test. He/she will complete other two trials. When the participant is sitting in the chair we will ask ***"Are you ready?".*** Then let go and begin timing as you say, ***"Ready, go".*** The stopwatch start when we said "go" and we stop the stopwatch when the participant sit down in the chair and touch the back with the backrest.

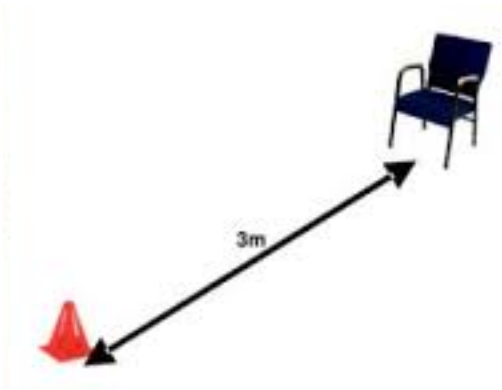
It does not exist limit time, so the participant can rest if is needed but cannot sit.

We will stop the test:

- Dizzy
- Instability
- General discomfort

Results: recommendation to the TUG is to distinguish those people that are independents in mobility and transfers (TUG < 20 seconds) from those people that are dependent, needs help to mobility or to transfers (TUG > 30 seconds).

Figure 9. 5 Schematic Illustration for the Timed Up and Go



SIT TO STAND 10

The scripts that have been used in the STS-10 are the following:

Moment to assess the test: previously the first or the second hemodialysis session of the week. Rather do it before the second hemodialysis session.

Material: stopwatches, a standardized chair, and a blood pressure machine, instructions and register sheets

Aim: To quantify lower-extremity muscle strength (force-generating capacity)

Procedure: The person has to be sitting correctly in a standardized chair with the back in the backrest. The chair may be stable to avoid fall risks during the test, so the chair will be all the time touching the wall. We asked the subject cross the arms in his/her chest and to get up and sit down from the chair 10 full and consecutive times. If is needed the person can use their usual aids and it will be registered in the sheets to evaluate the patient's evolution but it will not use for the analysis. The investigator will register the time that the participant needs to complete the test as quickly as possible. The participant is allowed to try if he/she can get up and sit down with arms cross in the chest.

Participant instructions:

"Now I will show you the next movement (demonstrate). ***Now I want you to rise from the chair 10 times with your arms cross in the chest. To start and to finish your back has to be against the backrest. You have to do it as fast as possible. I will count each repetition and I will record the time you need to complete this test."*** (Demonstrate the 10 repetitions and counting the times to get up and sit down from the chair). "***Imaging you are in the tenth repetition, in that point you have to stop in the sitting position with your back in the backrest"*** (It is important to specify in to finish in the sit position because a lot of patients stops when they get up).

We asked the participant to perform the first trial to become familiar with the test. He/she will complete other 10 trials. When the participant is sitting in the chair we will ask ***"Are you ready?"***. Then let go and begin timing as you say, ***"Ready, go".*** The stopwatch starts when we said "go" and we stop the stopwatch when the participant sit down in the chair and touch the back with the backrest in the repetition 10.

After the test we will pass the Rate of Perceived Exertion measured with a Borg Scale from 6 to 20 and we will measure the blood pressure and the heart rate after 10 minutes.

Results: We will record the time in seconds the patient needs to perform the test and the rate perceived exertion in the register sheets.

SIT TO STAND 60

The scripts that have been used in the STS-60 are the following:

Moment to assess the test: previously the first or the second hemodialysis session of the week. Rather do it before the second hemodialysis session. The STS-60 is performing 10 minutes later of the STS-10 when the blood pressure and the heart rate have decrease to baseline levels.

Material: stopwatches, a standardized chair, and a blood pressure machine or instruments, instructions and register sheets

Aim: To quantify lower-extremity muscle endurance

Procedure: The person has to be sitting correctly in a standardized chair with the back in the backrest. The chair may be stable to avoid fall risks during the test, so the chair will be all the time touching the wall. We asked the subject cross the arms in his/her chest and to get up and sit down from the chair during sixty seconds. If is needed the person can use their usual aids and it will be registered in the sheets to evaluate the patient's evolution but it will not use for the analysis. The investigator will register the repetitions that the participant complete. The participant is allowed to rest if is needed and to continue performing the task until the sixty seconds. Each repetition starts and finish at the sitting position, and if the participant is standing when the time is over, we will consider half a repetition.

Participant instructions:

"Now you are going to do the same test but this time I want you to rise and to sit down from the chair during one minute with your arms cross the chest. It consists in to achieve all the repetition you can do during one minute. I will count the number of times you get up and sit down. To start and to finish your back has to be against the backrest and I will count each repetition when the back touches the backrest. One minute is very long so if you need to rest you can rest but you have to continue getting up and sitting down as soon as possible. I will count each repetition and I will record the number of repetitions can complete during one minute." (It is important to specify that his/her back have to touch the backrest to count the repetitions. If the participant is standing when the time is over, we will consider half a repetition).

After the STS-10 we will measure the blood pressure and heart rate and when those are in the baseline levels we can start. When the participant is sitting in the chair we will ask ***“Are you ready?”***. Then let go and begin timing as you say, ***“Ready, go”.*** The stopwatch starts when we said “go” and we stop the stopwatch when the participant sit down in the chair and touch the back with the backrest after sixty seconds.

After the test we will pass the Rate of Perceived Exertion measured with a Borg Scale from 6 to 20

Results: We will record the number of repetitions the patient achieves and the rate perceived exertion in the register sheets.

HAND GRIP

The scripts that have been used in the Handgrip are the following:

Moment to assess the test: previously the first or the second hemodialysis session of the week. Rather do it before the second hemodialysis session.

Material: JAMAR dynamometer, chair without arm rests, table, stopwatch (time between each repetition), instructions and register sheets.

Aim: To quantify the force in each hand with a JAMAR dynamometer*

Procedure: The start position is with subject seated in a chair with feet in the floor and knees flexion 90 degrees. The arm that are we going to register will be with shoulder adduction and neutrally rotation, elbow flex 90 degrees in the table, wrist and forearm semi-pronation (0-30 degrees) and an ulnar deviation of the grip between 0 and 15 degrees. Proximal inter-phalangeal have to grip the handle and be flex 90 degrees. According to Mathiowetz et al 1984, the handle will be in the second position counting from proximal. We always start with dominant hand. Before start we will ask the patients about his/her dominant arm and we will register. The individual has to squeeze each trial among three seconds. The subjects will perform three trials with each hand and we respect between each repetition an interval of fifteen seconds to avoid fatigue. The investigator will register the repetitions in kilograms and we will analyze the higher mark.

Participant instructions:

"Now I want you to be seated in the chair with knee flexion of 90º and your feet in the floor. Are you a right-handed or left-handed? (The dominant has is tested first) ***I want you to hold the handle like this*** (demonstrate) ***and squeeze progressively and achieve as hard as you can.*** After the subject is positioned appropriately, the examiner says: ***"Are you ready? Squeeze as hard as you can"*** and the subjects begins to squeeze, say, ***"Harder! Harder! Relax".*** After the first trial score is recorded, the test is repeat with the same instructions for the second and the third trial and for the other hand.

Results: We will record the kilograms the participant achieves in each trial with each hand and we will analyze the maximum mark of each hand.

* A JAMAR dynamometer is a hydraulic instrument that measures the force in pounds (200 pounds maximum reading) and kilograms (90 kg maximum reading) with a maximum voluntary contraction.

ONE LEG HEEL RISE

The scripts that have been used in the One Leg Heel Rise are the following:

Moment to assess the test: previously the first or the second hemodialysis session of the week. Rather do it before the second hemodialysis session.

Material: metronome, wall to assist the subject, instructions and register sheets.

Aim: To quantify functional strength of the triceps sural muscle in each leg.

Procedure: The person has to be only with socks (no foot-wear). Before the test participant is asked to maintain the balance standing by one leg in the start position (back against the wall without touch it, arms in abduction, elbow extension and fingers touching the wall). Participants cannot available to use their arms to get rise. Subject has to raise the heel without knee flexion. The metronome's rhythm is a sound per each second, so in one sound the subject has to raise the heel and in other sound go down the heel. Count the number of repetition and stops if arrives to 25 repetitions. The investigator will register the repetitions that the participant complete.

Participant instructions:

"Now I want you to be with your back against the wall with your arms open/separated from your body, with your elbows extended. Only your fingers have to touch the wall. You will start in one leg stand position and with the balance leg you have to raise your heel without flexion your knee with the metronome rhythm. You have to achieve 25 repetitions or you can stop when you feel fatigue and you cannot continue doing the movement (demonstrate). ***I will count each repetition"***

When the participant is in the start position we will ask ***"Are you ready?"***. Then let go and begin counting the repetitions as you say, ***"Ready, go".*** The test finishes when the participant leaned or pushed against the wall or their knees were flexed, according to the examiner's observation, when they perform 25 repetitions.

After doing with one leg we will record the number of repetitions and the perceived exertion and we will test the contralateral leg.

Results: We will record the number of repetitions the patient achieves with each leg and the rate perceived exertion per each leg in the register sheets.

THE 6 MINUTES WALKING TIME

The scripts that have been used in the 6MWT are the following:

Moment to assess the test: previously the second or third hemodialysis session of the week. Rather do it before the third hemodialysis session because by at the end of the week the extra-fluid retained by the participants is at its lowest level, minimizing its influence on the results.

Material: stopwatch, a corridor with 20-30 meters, tape to place every two meters, two cones, a chair, a blood pressure and heart rate measured, the RPE scale instructions and register sheets. (It is better to use a 30 meters' corridor)

Aim: To assess the distance that a patient can quickly walk on a corridor, hard surface in a period of 6 minutes. It evaluates the global and integrated responses of all the systems involved during exercise

Procedure: The 6 MWT is performed in a 20-30 meters' corridor (depending in the HD unit) located in the hemodialysis unit. Tape is place every two meters. Before the test the register has to take into account any precautions or contraindications to exercise testing, has to record the blood pressure and the heart rate. The patient should sit at rest in a chair, located near the starting position, for at least 10 minutes before the test starts. During this time check for contraindications, measure pulse and blood pressure. Participants are ask to walk the longest distance possible in 6 minutes by walking the distance (20-30 meters) indicate on the floor, turn around at the final mark (a cone) without stopping. To achieve the test participants are allowing to use the aids they use in their daily life and the researcher has to register it. The standardized order given to the participants was "walk as far as possible for 6 minutes, but do not run or jog". They can turn down their velocity or stop if needed and restart later. Heart rate and blood pressure are measure before and immediately after the test. The investigator registers the distance cover and the degree of difficulty determinate by the RPE at the end of the test.

Absolute contraindications: unstable angina during the previous month and myocardial infarction during the previous month.

Relative contraindications: resting heart rate of more than 120, a systolic blood pressure of more than 180 mmHg, and diastolic blood pressure of more than 100 mmHg.

Participant instructions:

"Now you are going to do a six-minutes walking test. The object of this test is to walk as long as possible for 6 minutes, so you have to walk quickly without run or jog. Six minutes is a long time to walk, so will be exerting yourself. You will probably get out of breath or become exhausted. You are permitted to slow down, to stop and to rest as necessary. You may lean against the wall while resting, but resume walking as soon as you are able. You will be walking back and forth around the cones. You should pivot briskly around the cones and continue back the other way without hesitation. Now I am going to show you. Please watch the way I turn without hesitation (demonstrate by walking one lap yourself. Walk and pivot around a cone briskly)***. You will be kept informed of the time and you will be encouraged to do your best. I´m going to keep track of the number of laps you complete. Please do not talk during the test unless you have a problem or if I ask you a question. You must let me know if you have any chest pain or dizziness. When the six minutes is up I will ask you to stop where you are. Do you have any question?***

When the participant is in the start position we will ask ***"Are you ready?" Remember that the object is to walk AS FAR AS POSSIBLE for 6 minutes, but do not run or jog***. Then let go and begin counting the distance as you say, ***"Ready, go".*** The test finishes when the participant achieves the six minutes or when the participants feel chest pain, intolerable dyspnea, leg cramps, pale or ashen appearance.

During the test the researcher has to monitor the patient for untoward signs or symptoms. He/she has to use standard encouragements during the test:

- At minute one: ***"You are doing well. You have 5 minutes to go"***
- At minute two: ***"Keep up the good work. You have 4 minutes to go"***
- At minute three: ***"You are doing well. You are halfway done"***
- At minute four: "***Keep up the good work. You have only 2 minutes left"***
- At minute five: ***"You are doing well. You have only 1 minute to go"***

If the patient stops walking during the test and needs a rest, say this: ***"You can lean against the wall if you would like; then continue walking***

whenever you feel able" Do not stop the timer. If the patients stop before the 6 minutes are up and refuses to continue (or you decide that they should not continue), wheel the chair over for the patient to sit on, discontinue the walk and note on the worksheet the distance, the timed stopped, and the reason for stopping prematurely.

When the timer s 15 seconds from completion, say this: "***In a moment I am going to tell you stop. When I do, just stop right where you are and I will come to you"***

When the timer rings say this ***"Stop"*** Walk over to the patient. Consider taking the chair if they look exhausted. Mark the stop where they stopped by placing a beanbag or a piece of tape on the floor.

Post-test we will measure the blood pressure and the heart rate and the RPE will be recorded

Results: We will record the number of laps from the tick marks on the worksheet.

APPENDIX 3. INTRADIALYTIC DIARY

DIARIO MES__________________ RM____________________

DURANTE HD													
	Nombre /dia												
	Sistólica inicio/fin												
	Diastólica inicio/fin												
	FC inicio / fin												
ESTIRAMIENTOS	**Triceps sural**												
	Isquiotibiales												
	Mov. de cadera												
PESAS	**Cuádriceps**												
	serie												
	repeticiones												
	kg												
BANDA ELÁSTICA	**Triple extensión**												
	serie												
	repeticiones												
	color												
	Tríceps sural												
	serie												
	repeticiones												
	color												

PELOTA	**ADD/glúteos**												
	serie												
	repeticiones												
	tiempo												
	Isquiotibiales												
	serie												
	repeticiones												
	tiempo												
BICICLETA	**Velocidad**												
	Resistencia												
	Distancia												
	Tiempo												
ESTIRAMIENTOS	**Triceps sural**												
	Isquiotibiales												
	Mov. de cadera												

APPENDIX 4. HOME – BASED PROTOCOL

PROGRAMA HOME BASED

UNIVERSIDAD CEU-CARDENAL HERRERA
Fisioterapia en la Insuficiencia Renal Crónica
2014/2015

¡BIENVENIDO!

Vamos a empezar a realizar el ejercicio en casa, ¿Está preparado/a?

En este folleto viene toda la información necesaria para que usted pueda comprender y realizar el protocolo de actividad física que llevará a cabo en su casa durante los próximos 4 meses.

El objetivo fundamental de este programa es adquirir el HÁBITO DE EJERCICIO en pacientes con insuficiencia renal crónica que acuden a hemodiálisis, para poder obtener los beneficios del ejercicio regular.

El programa de ejercicios que está a punto de comenzar, está especialmente diseñado para usted. Como seguramente sabe, realizar ejercicio físico tiene grandes beneficios. Gracias a este programa usted podrá mejorar las siguientes cualidades:

- Capacidad aeróbica. Andar y bailar son formas de ejercicio aeróbico que consisten en el movimiento rítmico de grandes grupos musculares y obligan al sistema cardiovascular a trabajar a un alto nivel para distribuir oxígeno a los músculos que se contraen.
- Fuerza muscular. Los ejercicios de fortalecimiento ayudan a mejorar la coordinación y el equilibrio, y por lo tanto pueden prevenir caídas. Además la tracción muscular sobre el hueso facilita la calcificación del esqueleto.
- Flexibilidad. La realización de estos ejercicios permite aumentar la movilidad de las articulaciones y mejorar la realización de muchas actividades de la vida diaria.
- Calidad de vida relacionada con la salud.

¿CUÁLES SON LOS BENEFICIOS DEL EJERCICIO?

El ejercicio es un tipo de actividad física. Movimiento estructurado, repetitivo para mejorar o mantener los componentes de la forma física.

- Mantiene la masa ósea y aumenta la masa muscular
- Disminuye el riesgo de caídas y por lo tanto el riesgo de fracturas que resultan tras una caída
- Mejora la función cardiovascular y respiratoria: disminuye la frecuencia cardiaca y la presión arterial, aumenta la capilaridad muscular, protege frente a la angina de pecho y aumenta la capacidad pulmonar
- Reduce mortalidad y enfermedad: prevención de enfermedades (el aumento de actividad está asociado a una menos incidencia de enfermedad cardiovascular y coronaria, diabetes tipo II, obesidad y osteoporosis), disminuye la ansiedad y depresión, mejora el bienestar, mejora la realización de las actividades de la vida diaria y actividades de ocio.

¿HAY RIESGOS ASOCIADOS CON EL EJERCICIO?

- El ejercicio intenso aumenta las demandas del miocardio y esto puede resultar en problemas cardiovasculares en personas con enfermedad cardiaca conocida u oculta.
- El cese BRUSCO de ejercicio puede contribuir a una falta de oxígeno en el corazón, por lo que es importante un descanso progresivo de pulsaciones tras el ejercicio.
- Algunos problemas cardiacos podrían aparecer como consecuencia de un aumento BRUSCO de frecuencia cardiaca y presión arterial, por lo que es importante un incremento progresivo de las pulsaciones.

La CUESTION CLAVE es si los beneficios superan los riesgos…el riesgo de complicación cardiovascular durante el ejercicio es bajo especialmente cuando se sopesa con los beneficios asociados.
El ejercicio regular protege contra el infarto de miocardio agudo y otros fallos cardiacos durante una actividad física intensa.

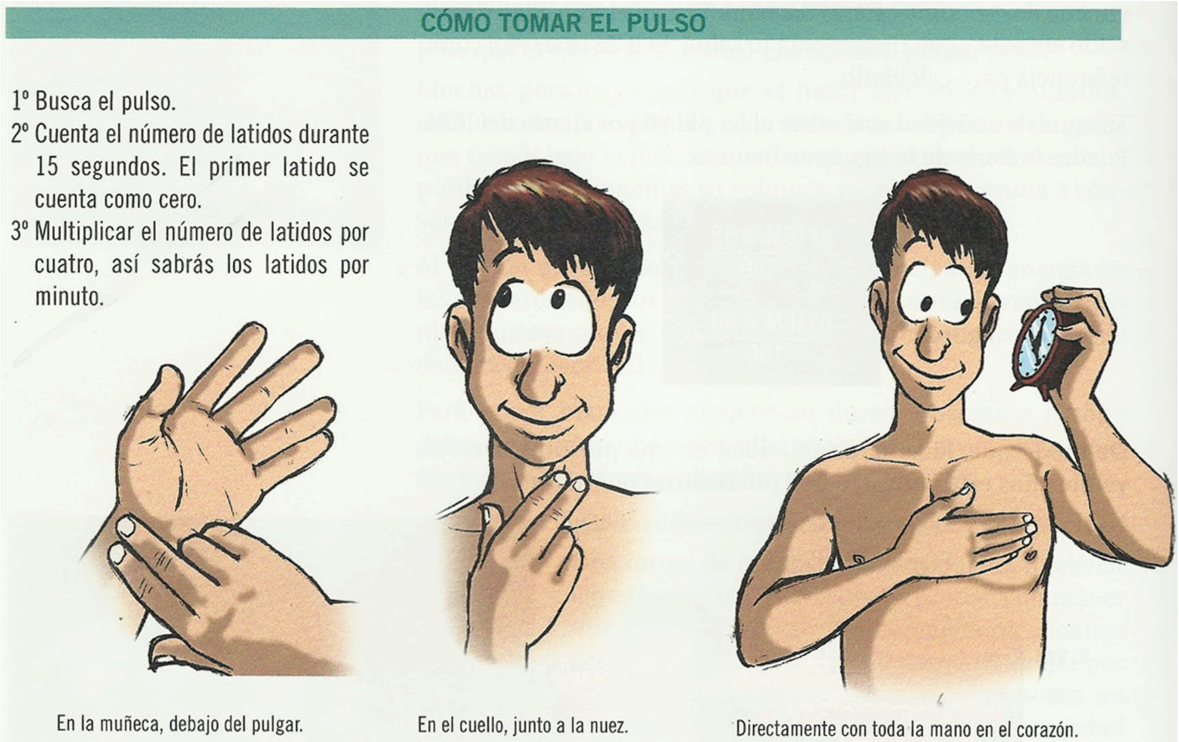
Antes de iniciar el programa de ejercicio, lea atentamente las siguientes líneas:

- Deberá realizar los ejercicios un total de 3 veces por semana, en ningún caso deberá ser inferior a este número y los días en que realice los ejercicios serán, de forma ideal, en días alternos (por ejemplo: lunes, miércoles y viernes)
- El tiempo estimado de cada sesión no debe ser inferior a 45 minutos
- El material necesario para cada sesión será: calzado y ropa deportiva cómoda, cronómetro y el material que le facilite la fisioterapeuta

Una vez usted haya terminado la sesión de ejercicios, deberá respirar hondo al menos 3 veces, a fin de eliminar la fatiga.
Durante las primeras sesiones del programa, es posible que sienta un poco de rigidez muscular (agujetas). Esto se debe a que posiblemente usted este empleando músculos que no está acostumbrado a ejercitar. **Es importante que complete la sesión, pese a que tenga que reducir la intensidad del ejercicio**. Esta rigidez desaparecerá progresivamente a medida que avancen las sesiones y se familiarice con el ejercicio.

RECOMENDACIONES para disminuir riesgo de complicaciones durante el ejercicio

- Es importante saber tomarse el pulso en el cuello o en la muñeca, nunca con el dedo pulgar. Contabilice el número de pulsaciones por 15 segundos. Mantenga la frecuencia cardiaca dentro de los valores recomendados. Marque en la escala de esfuerzo percibido el grado de intensidad del ejercicio realizado, y manténgase en los valores prescritos.



- Si experimenta dolor torácico, dolor de cabeza, palpitaciones, fatiga muscular o respiración recortada acuda el médico porque podría indicar complicación cardiovascular.
- Son importantes los periodos de calentamiento y de descanso de pulsaciones tras la realización del ejercicio aeróbico.
- Beba agua antes, durante y después de realizar ejercicio.
- Utilice ropa ligera, incluso pantalón corto si lo necesita.

CONSIDERACIONES IMPORTANTES A TENER EN CUENTA

- Es muy importante realizar las sesiones todas las semanas, incluso en vacaciones y **anotar en el calendario facilitado la fecha y duración de cada sesión**. Una vez acabado los 4 meses de ejercicio deberá llevar este diario a la unidad de hemodiálisis para entregárselo a la fisioterapeuta del programa.
- Si durante el transcurso de la sesión aparecen dolor, molestias o mareos, DETENER la sesión. **El cansancio no es una molestia.**
- Realizar la sesión de ejercicio un mínimo de 2 horas después de la digestión.

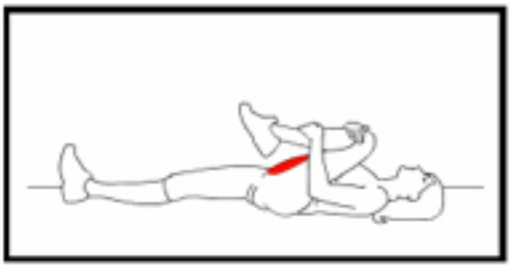
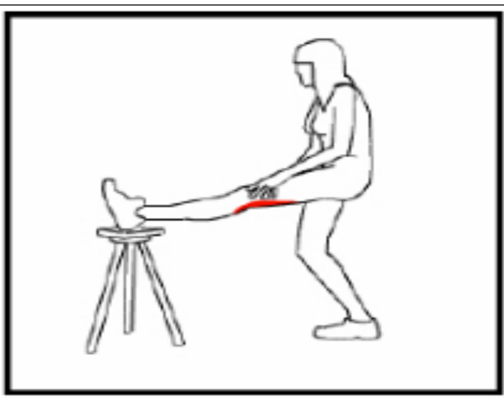
- NO realizar la sesión con la televisión encendida
- NO excederse en la cantidad de ejercicio
- Respetar tiempos y repeticiones.
- Es importante la posición del cuerpo adoptada en el ejercicio. La columna recta y algo de tensión abdominal en todos los ejercicios (ombligo presionando la columna). Fíjese en las imágenes e instrucciones.
- En caso de existir cualquier duda sobre el ejercicio, póngase en contacto con la fisioterapeuta

¡¡DISFRUTE DEL EJERCICIO!!

DESCRIPCIÓN DEL PROGRAMA

Inicio de la sesión:

- 3 minutos de marcha (busque un pasillo, camine entre habitaciones en su casa)
- Estiramientos de cadena posterior

 Gemelos -	 Sóleos
 Biceps femoral especifico	 Cuádriceps
 Isquiotibiales Genérico	 Aductores de sentado

*Tiempo mínimo de estiramiento 20 segundos cada estiramiento. Realizar 1 repetición con cada pierna. Realizar cada estiramiento alternando las piernas (por ejemplo, si realizamos el estiramiento de isquiotibiales empezamos con una pierna, cuando acabemos lo hacemos con la otra pierna y luego volveremos otra vez a la primera. Así sucesivamente hasta llegar a las 3 repeticiones con cada pierna)

1. Ejercicio de cuádriceps: Sentado con peso en el tobillo o banda elástica cogida en la pata trasera de la silla. Apoyar bien la espalda en el respaldo. Empezar con el pie apoyado en el suelo y estirar la rodilla. Estirar la pierna en dos segundos, aguantar 2 segundos y 4 segundos para volver a bajar la pierna.

Realizar 1 serie de 10 repeticiones, como si percibiera un esfuerzo entre 12 y 15 en la escala que se adjunta en la última hoja.

Realizar primero una pierna, y luego la otra

MODIFICACIONES

1 minuto marcha rápida

2. Ejercicio de cuádriceps con apoyo*: apoyado en una mesa o en la pared. Flexionar las rodillas en 4 segundos, aguantar dos segundos y subir en 2 segundos.

Realizar 1 series de 10 repeticiones

MODIFICACIONES

***Ejercicio de cuádriceps sin apoyo**: Estar con la espalda recta y las manos en las caderas. Flexionar rodillas en 4 segundos, aguantar dos segundos y volver a estirar las piernas en 2 segundos

Realizar 1 series de 10 repeticiones

1 minuto marcha rápida

3. Levantarse y sentarse de la silla: En una silla con reposabrazos. Sentado mirando al frente, con las manos sobre el reposabrazos de la silla, los pacientes deberán realizar una inclinación hacia delante y se incorporarán hasta ponerse de pie (ponerse de pie en dos segundos, aguantar dos segundos y bajar en 4 segundos). Personalizar apoyo de las manos y poner cargas para dificultarlo.
Realizar 1 series de 10 repeticiones.

MODIFICACIONES

Ir quitando los apoyo hasta realizarlo con los brazos cruzados en el pecho

1 minuto marcha rápida

4. Ejercicio de isquiotibiales con apoyo: De pie, apoyado en una mesa o en la pared. Poner peso en el tobillo o con banda elástica pisando uno de los extremos con el pie que no hace el ejercicio. Doblar la rodilla, llevando el talón hacia el glúteo en dos segundos, aguantar 2 segundos y volver a estirar la pierna en 4 segundos.

Realizar 1 series de 10 repeticiones

Realizar primero una pierna y luego la otra

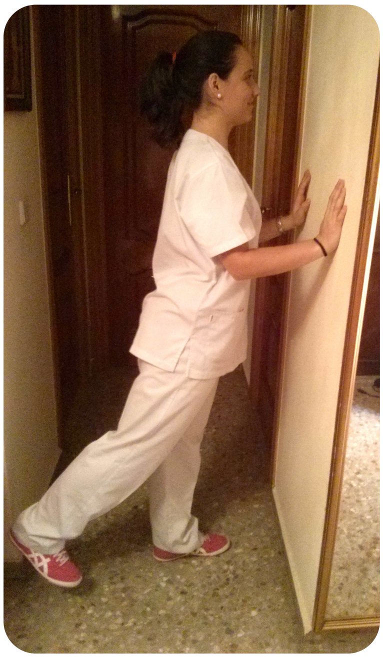
MODIFICACIONES

1 minuto marcha rápido

5. Glúteos: Con la pierna recta, llevar el talón hacia atrás.

Realizar 1 series de 10 repeticiones

Realizar primero una pierna, cambiar a la otra.



MODIFICACIONES

1 minuto marcha rápida

6. Ejercicios de abductores: De pie, apoyado en una mesa o en la pared con la pesa en el tobillo o la banda elástica enganchada por uno de los extremos. Llevar la pierna hacia el lado (no inclinar el tronco hacia ninguno de los lados). Separar en dos segundos, aguantar en dos segundos y volver en 4 segundos.

Realizar 1 serie de 10 repeticiones

Realizar primero una pierna y luego la otra

MODIFICACIONES

1 minuto marcha rápida

7. Elevación de talones: puntillas en el suelo, con los dos pies. Sujetarse en una silla o en la pared. Subir en un segundo, mantener 3 segundos y bajar en dos segundos.

Realizar 1 series de 15 repeticiones.

Aguantar entre serie y serie un minuto

MODIFICACIONES

Ponerlo más difícil según la persona, quitándole el apoyo o realizándolo a la pata coja o poniéndole carga

1 minuto marcha rápida

8. Ejercicios para el equilibrio

a) Se le pedirá al paciente que, estando de pie apoyado en la pared, coloque un pie directamente delante del otro de manera que queden el línea recta (tándem). Si el paciente no puede ponerse en esta posición partiremos de una posición de semitándem (el talón de un pie toca el dedo gordo del otro a una altura media) y poco a poco iremos avanzando el pie hasta llegar a la posición de tándem. El paciente deberá aguantar durante 10 segundos esta posición. Empezaremos apoyándonos en la pared y poco a poco lo iremos haciendo sin apoyo.

Se repetirá dos veces. Realizar dos veces

MODIFICACIONES

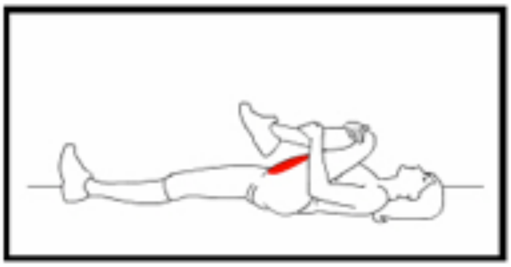
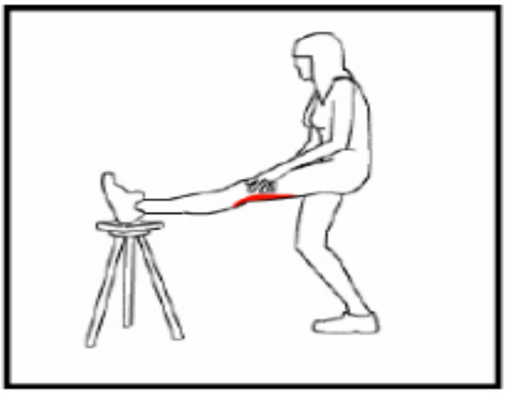
1 minuto marcha rápida

b) Aguantar a la pata coja con apoyo durante 10 segundos e ir incrementando el tiempo para añadir dificultad. Una vez se encuentre seguro pasará a realizarlo sin apoyo durante 10 segundos e incrementará el tiempo hasta llegar a 45 segundos (tiempo máximo). Realizar 3 veces con cada pierna (ir intercalándolas)

MODIFICACIONES

1 minuto marcha rápida

Al acabar todos los ejercicios caminar durante 15-30 minutos a una velocidad normal y realizar estiramientos de cadena posterior

 <u>*Gemelos*</u> -	 Sóleos
 <u>*Bíceps femoral específico*</u>	 <u>*Cuádriceps*</u>
 <u>*Isquiotibiales Genérico*</u>	 <u>*Aductores de sentado*</u>

*****Tiempo mínimo de estiramiento 20 segundos cada estiramiento. Realizar 3 repeticiones con cada pierna. Realizar cada estiramiento alternando las piernas (por ejemplo, si realizamos el estiramiento de isquiotibiales empezamos con una pierna, cuando acabemos lo hacemos con la otra pierna y luego volveremos otra vez a la primera. Así sucesivamente hasta llegar a las 3 repeticiones con cada pierna)

¡¡ENHORABUENA!!

EL EJERCICIO FÍSICO MEJORA SU SALUD

ÁNIMO Y DISFRUTE CON EL PROGRAMA

Si usted tiene alguna duda o algún problema, consúltelo con la coordinadora del programa

Contacto:

Lucía Ortega Pérez de Villar

Teléfono 661161547

Email: lucia22190@gmail.com

APPENDIX 5. THE BORG RATING OF PERCEIVED EXERTION SCALE

BORG SCALE RPE SCALE

This table is used as a quantitative measure of perceived exertion while you are doing exercise. Look at the table and chose the number that best describes how you feel after exercise.

6	**No exertion at all**	
7	**Extremely light**	
8		
9	**Very Light**	
10		
11	**Light**	
12		
13	**Somewhat hard**	
14		
15	**Hard (heavy)**	
16		
17	**Very hard**	
18		
19	**Extremely hard**	
20	**Maximal exertion**	

APPENDIX 6. RESEARCH STAY

VICERRECTORADO DE INVESTIGACIÓN Y RELACIONES INTERNACIONALES	UCH-CEU

Work placement certificate from HOST ORGANIZATION

PROJECT Nº: 2011-1-ES1-LEO02-34142

PARTICIPANT: LUCÍA ORTEGA PEREZ DE VILLAR WAS OUR TRAINEE FROM: 3/12/12 TO: 29/05/13

FROM MONDAY TO FRIDAY, FROM: 9 a.m TO: 6 p.m

COMPANY: QUEEN MARGARET UNIVERSITY

QUEEN MARGARET UNIVERSITY DRIVE

EDINBURGH EH21 6UU

TUTOR (name, position, telephone & mail)
Name: TOM MERCER Position: Professor of Clinical Exercise Physiological and Rehabilitation Telephone: +44(0) 131 474 0000 Mobile: +44(0) 7919432688 Fax: +44 (0) 131 474 0001 Mail: tmercer@qmu.ac.uk
TASKS CARRIED OUT BY THE PARTICIPANT DURING THE PLACEMENT (min. 100 words)
December 2012: University induction. Introduction to the Haemodialysis Unit and relevant haemodialysis protocols. Medical History review of patients. Observation of assessment and exercise training procedures January 2013: Review of methods for the outcome assessment of physical function and psychosocial evaluation in stage 5 CKD patients. Observation of outcome assessment of patients. Preliminary statistical analysis and interpretation of secondary data from pre-existing Haemodialysis patient database. Attendance at Postgraduate Physiotherapy Research Proposal Presentation Seminars February 2013: Literature search to support the identification and acquisition of validated Spanish language versions of key patient reported outcome assessments relating to frailty and physical performance capability monitoring of patients with stage 5 CKD (Haemodialysis). Production of a summary report (based on the secondary data analysis) on Walking Impairment and activity of daily living related functional capacity March 2013: Preparation for and discussions about an outline structure for a narrative systematic review on Frailty assessment and monitoring in people with chronic kidney disease. Preliminary and exploratory literature searches for narrative systematic review on Frailty assessment and monitoring in people with chronic kidney disease. Attempts to obtain April 2013: Establish literature “search terms”, eligibility criteria and general review strategy. Complete Literature search for narrative systematic review on Frailty assessment and monitoring in people with chronic kidney disease. Establish contact with experts in Frailty research to support this review process. Introduction to and acquisition of basic skills in the use of high-resolution ultrasound for the assessment and monitoring of muscle mass and architecture in people with chronic kidney disease. May 2013: Production of a final draft narrative systematic review on Frailty assessment and monitoring in people with chronic kidney disease

EVALUATE THE ACTIVITY CARRIED OUT BY THE GRADUATE

		FAILED	PASS	GOOD	VERY GOOD
Evaluate the previous education of the participant in order to accomplish the different tasks assigned at the company	▪ Techical Knowledge ▪ Personal Skills ▪ Language			X X	 X
Participant integration at the company from the following points of view	▪ Technical ▪ Human			X	 X
Evaluate on achieving the proposed training agreement and aims of the placement				X	
General satisfaction with this work placement at your company					X

ABOUT THE SERVICE OFFERED BY UCH-CEU

	FAILED	PASS	GOOD	VERY GOOD
Satisfaction with the UCH-CEU International Office				
Would you like to have more Leonardo participants in the future?	**YES**	X		

OTHER REMARKS

Ms Lucia Ortega was an excellent participant in this Leonardo scheme. She was a diligent, highly competent and enthusiastic addition to our working team. Lucia was an excellent ambassador for, and credit to, her university (CEU) and was a delight to supervise. Lucia's committed and insightful participation in this programme have gone a long way to encouraging our School to consider wider participation in this scheme. I look forward to extending the working relationship and collaboration, developed by this scheme, with colleagues at CEU.

Hereby we declare that the above mentioned participant has fulfilled a training placement under the above described conditions, under the mobility project M.O.B.I.3, funded by the Leonardo da Vinci Programme of the European Commission's Life Long Programme within our Organization.

Date: 30/08/2013

SIGNATURE COMPANY'S TUTOR

M. Mercer

Name and Stamp

Professor Tom MERCER

QUEEN MARGARET UNIVERSITY
EDINBURGH EH21 6UU
Tel: +44(0)131-474-0099

APPENDIX 7. PAPER 1

ORIGINAL

Cuantificación del deterioro funcional durante seis meses en pacientes renales en estadio terminal

Lucía Ortega Pérez de Villar[1], Sara Antolí García[2], Mª Jesús Lidón Pérez[3], Juan José Amer Cuenca[4], Javier Martínez Gramage[5], Eva Segura Ortí[6]

[1,2,3,4,5,6]Fisioterapeuta. Departamento de Fisioterapia Universidad CEU Cardenal Herrera. [3]Supervisora de Enfermería, Hospital Universitario Doctor Peset. Valencia. España

Resumen

Introducción: Los pacientes en tratamiento de diálisis presentan una disminución de la función física, sin embargo, no hay estudios que demuestren el ritmo al que se produce este deterioro funcional. El objetivo principal es cuantificar el deterioro funcional de los pacientes en tratamiento de diálisis durante seis meses.

Métodos: 43 pacientes en tratamiento de diálisis de dos centros de Valencia (España) (edad 61.3 (14.7) años) fueron analizados después de 6 meses. Los participantes completaron el Short Physical Performance Battery, equilibrio monopodal, el Timed Up and Go Test, Sit to stand to Sit Test 10 y 60, dinamometría de mano; elevación de talón y 6 minutos marcha. Además se recogieron datos de las historias clínicas y de las analíticas.

Resultados: Tres de las pruebas mejoraron significativamente tras el periodo de 6 meses de observación: el Sit To Stand 10, la dinamometría de la mano derecha y la dinamometría de la mano izquierda, pero sin alcanzar un cambio clínico relevante. Por otro lado, otras medidas no obtuvieron un deterioro significativo como fueron el Short Physical Performance Battery, el Sit to Stand 60, la elevación del talón izquierdo y el 6 minutos marcha.

Conclusiones: Después de 6 meses, en ninguna de las pruebas de capacidad funcional se observa un deterioro significativo. Se recomienda a los centros de hemodiálisis realizar un seguimiento de capacidad funcional anualmente, ya que con un periodo de 6 meses no se encuentran cambios significativos.

PALABRAS CLAVE
- INSUFICIENCIA RENAL CRÓNICA
- CAPACIDAD FUNCIONAL
- DETERIORO FUNCIONAL

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lucia.ortega@uchceu.es

Quantification of functional impairment for six months in hemodialysis patients

Abstract

Introduction: Patients in dialysis treatment present a decrease in physical function. However, we cannot find in the literature the rhythm of the functional deterioration. The main aim is quantify the functional deterioration in patients undergoing haemodialysis during six months period.

Methods: 43 patients in dialysis treatment from two centres from Valencia (Spain) (age 61.3 (14.7) years old) were recruited and monitored after the 6 months period. Study participants performed the Short Physical Performance Battery, one leg stand, TUG, Sit to Stand 10 and 60, handgrip dynamometry, the one leg heel rise and the 6 minutes walking time.

Outcomes: Three tests improve significantly: the Sit to Stand 10, the right and the left Handgrip Dynamometry. Nevertheless, we cannot observe a significant deterioration as the Short Physical

Performance Battery, the Sit to Stand 60, the one leg heel rise in the left leg and the 6 minutes walking time.

Conclusions: After 6 months, we have not observed a significant deterioration in the tests. We recommended the different units to follow the functional capacity of the patients yearly, because with a period of 6 months we have not find significantly changes.

KEYWORDS
- CHRONIC KIDNEY DISEASE
- FUNCTIONAL CAPACITY
- FUNCTIONAL DETERIORATION

Introducción

La insuficiencia renal crónica (IRC) en estadio terminal presenta una prevalencia que va en aumento de año en año. En Europa, la prevalencia por millón de habitantes pasó de 779 en 2006 a 881 en 2008, mientras que en España en este mismo periodo la prevalencia presentó cifras superiores, pasando de 983 a 994 casos por millón de habitantes. La terapia renal substitutiva más común para las personas con este tipo de patología es la hemodiálisis (HD)[1,2]

Los pacientes en tratamiento de HD presentan una disminución de la capacidad funcional[3]. Esta alteración funcional ya es evidente en estadíos previos de insuficiencia renal[4,5], aunque no se conoce si está asociada a la disminución de la tasa de filtrado glomerular o a otros factores asociados con la IRC. Los pacientes en HD tienen un nivel de actividad física significativamente inferior al que presentan sus homólogos sanos[6]. Se desconoce a qué ritmo disminuyen la capacidad funcional y el nivel de actividad física de los sujetos en HD. Las alteraciones a nivel muscular son comunes en los pacientes con IRC terminal, entre las que se encuentran la reducción de la sección transversal, los cambios degenerativos y las alteraciones metabólicas[7,8,9]. Estas alteraciones actúan como factores limitantes de la capacidad funcional[10]. Además, es común encontrar en HD un bajo nivel de calidad de vida relacionada con la salud, asociada frecuentemente a la presencia de depresión y ansiedad[11,12,13,14,15]

El objetivo principal de este estudio es cuantificar el deterioro funcional de los pacientes en tratamiento de hemodiálisis durante seis meses.

Material y Métodos

Sujetos

Se incluyeron cuarenta y tres pacientes (28 hombres y 15 mujeres) con insuficiencia renal crónica en estadio terminal de la unidad de diálisis al Hospital Virgen del Consuelo de Valencia y del Hospital Universitario Doctor Peset (España) para participar en el estudio entre octubre de 2014 y enero de 2015.

Los criterios de inclusión fueron: estar al menos 3 meses en tratamiento de hemodiálisis y encontrarse estable médicamente. Los criterios de exclusión fueron: (1) Infarto de miocardio en las 6 semanas previas (2) angina inestable al ejercicio o en reposo (3) amputación de miembros inferiores por encima de rodilla sin prótesis (4) enfermedad vascular cerebral (ictus, isquemias transitorias) (5) alteraciones músculo-esqueléticas o respiratorias que empeoren con las pruebas funcionales (6) imposibilidad de realizar las pruebas funcionales.

Se tomaron los siguientes datos clínicos al inicio del estudio: edad, peso seco, índice de masa corporal, tiempo en HD, horas de HD a la semana, índice de comorbilidad de Charlson.

La capacidad física funcional se midió al inicio y a los 6 meses sin realizar ningún tipo de intervención, los participantes tenían que realizar su vida normal.

El estudio fue aprobado por el Comité de Ética de la Universidad CEU Cardenal Herrera y por el Comité Ético de Investigación del Hospital Universitario Doctor Peset de Valencia, y los participantes firmaron el consentimiento informado. La investigación se realizó dentro de las pautas marcadas por la Declaración de Helsinki de 1975.

Capacidad física funcional

Las pruebas funcionales encaminadas a evaluar la condición física de los pacientes fueron el *Short Physical Performance Battery (SPPB)*, el equilibrio monopodal, el *Timed up and go (TUG)*, el *Sit to stand to sit test* 10 y 60 (STS 10 y STS 60) , la dinamometría de mano, la fuerza de tríceps sural, y el 6 minutos marcha (6MWT).

La prueba Short Physical Performance Battery (SPPB) se registró el primer día antes de la sesión de HD. Consta de tres pruebas de equilibrio, con los pies juntos, en posición de semitándem y en tándem, y se valora si el sujeto puede mantener cada una de estas posiciones hasta un máximo de 10 segundos. La valoración del equilibrio va de 0 a 4 puntos. Incluye también una prueba de velocidad de la marcha en 4 metros a velocidad habitual. Se realizaron dos intentos cronometrados y se registró el mejor de ellos, de forma que, según los segundos empleados, se asignó una puntuación de 1 a 4. Se valoró también la prueba STS-5, que consiste en medir el tiempo empleado en levantarse y sentarse de la silla 5 veces con los brazos cruzados en el pecho, deteniendo el cronómetro cuando el paciente alcanzaba la posición de pie en la repetición 5. Según el tiempo empleado se asignó una puntuación de 0 a 4 puntos. Por lo tanto, la puntuación del SPPB va de 1 a 12 puntos [16].

Se valoró también el equilibrio estático monopodal antes de la primera sesión semanal de HD, pidiendo a los sujetos que levantasen una pierna flexionándola de forma que se pusieses a la pata coja, con la pierna que se encontrasen más seguros. Se les pidió que aguantasen el equilibrio el mayor tiempo posible. El fisioterapeuta anotó el tiempo que el paciente aguantaba en posición de apoyo monopodal. El sujeto podía mover los brazos y flexionar la rodilla si lo necesitaba para mantener el equilibrio. El tiempo finalizaba cuando el sujeto usaba sus brazos para apoyarse, utilizaba el pie elevado para apoyarse en el suelo, cuando el pie apoyado se movía para mantener el equilibrio o cuando el tiempo llegaba a los 45 segundos. Se repitió el procedimiento 3 veces y se registró el mejor tiempo[17].

La prueba 'Timed Up and Go' (TUG)[18,19], también se realizó previamente a la primera sesión de hemodiálisis. Desde una silla el paciente se tenía que levantar, caminar 3 metros y volver a la posición inicial. Se repitió el procedimiento 3 veces y se registró el mejor tiempo.

La prueba de dinamometría de mano se realizó con el Dinamómetro JAMAR previamente al segundo día de la sesión semanal de HD. Según varios estudios en pacientes en diálisis, existe una correlación entre la fuerza de prensión de la mano con su estado de salud9, 20,21 . Los sujetos sentaban en una silla, con los pies apoyados en el suelo y las rodillas flexionadas 90°. El hombro del brazo que se estaba registrando permanecía en rotación neutra, con el codo en flexión de 90° apoyado en la mesa, muñeca y antebrazo semipronados (0-30°) y una desviación cubital entre 0 y 15°. Se realizaron 3 repeticiones consecutivas, con un descanso de 15 segundos entre ellas, en cada uno de los miembros superiores, comenzando por el brazo dominante. Se dio ánimo verbal en las repeticiones y se registró la de valor máximo.

El segundo día de la sesión semanal de hemodiálisis también se realizaron las pruebas del STS 10 y STS 60, tal y como describen Cüska y McCarty22. La primera consiste en medir los segundos que necesita el paciente para levantarse y volver a sentarse 10 veces consecutivas lo más rápido posible, desde una posición de sentado y con los brazos cruzados en el pecho. Tras realizar las 10 repeticiones se registró el tiempo que había necesitado para realizar la prueba, así como el grado de dificultad en la Escala de Esfuerzo Percibido (EEP) (Figura 1 EEP). A continuación, tras un periodo de recuperación de 3 minutos como mínimo, se realizó el STS 60. Se explicó al paciente que la prueba consistía en realizar el máximo número de repeticiones de levantarse y volver a sentarse en un tiempo de 60 segundos. Tras la realización de la prueba se registraron las repeticiones y se anotó el grado de dificultad de la prueba según la EEP.

La prueba de la fuerza del tríceps sural o prueba de elevación de talón monopodal, se realizó también inmediatamente antes de la segunda sesión semanal de HD[23,24,25]. Los pacientes debían de estar descalzos. El ritmo de elevación del talón se marcó mediante un metrónomo. Antes de iniciar la prueba se pidió al paciente que mantuviese el equilibrio sobre una sola pierna, con un apoyo ligero de las puntas de los dedos en la pared, con los brazos separados del tronco y evitando que trasladasen el peso a través de los brazos a la pared, mientras el pie contralateral se situó ligeramente elevado del suelo. Se permitió un intento de elevación con el pie izquierdo, tras el cual se procedió a valorar la elevación del talón derecho. Se les pidió que elevaran el talón todo lo que pudieses al ritmo del metrónomo hasta que no pudieses elevar el talón por fatiga muscular. Si el sujeto compensaba con los brazos contra la pared o flexionaba la rodilla terminaba la prueba. También finalizaba si alcanzaba las 25 repeticiones, pues se ha establecido que estas son las repeticiones que de media se encuentran en la población sana[23,24]. Se anotó el número de repeticiones por cada pierna así como el grado de dificultad según la EEP.

La prueba de 6 minutos marcha (6MWT) se realizó previamente a la tercera sesión semanal de hemodiálisis, en el pasillo de la unidad. En el momento previo a la realización de la prueba se registró, mediante un esfigmomanómetro digital, la tensión arterial y la frecuencia cardiaca en el brazo sin fístula. A continuación se le indicó al paciente que durante 6 minutos, debía recorrer la máxima distancia señalada por unas marcas en el suelo, girando sin parar cada vez que recorría 20 metros. La orden dada al paciente fue la siguiente: << tiene que intentar recorrer la máxima distancia posible en este pasillo de 20 metros, andando lo más rápido que pueda sin llegar a correr >>. Se permitió realizar el test con ayudas para la deambulación si el paciente las utilizaba en su vida diaria o con la asistencia de otra persona, o parar y reiniciar la marcha en caso de necesitar un descanso durante el test. Se registró la distancia recorrida y se pidió al paciente que describiera en la EEP cuál había sido el grado de dificultad de la prueba[14, 26].

Tabla 1. Datos descriptivos de la historia clínica.

Variables	Valores
Sexo (Hombre: Mujer)	28:15
Edad X(DE) Años	61.3 (14.7)
Tiempo en HD Mediana (min-max) meses	49 (18-382)
Índice de masa Corporal (Kg/m²) Mediana (min-max)	24.45 (20.32-39.39)
Etiología	
• **Diabetes Mellitus**	9
• **Glomerulonefritis**	10
• **Nefroanfiesclerosis**	3
• **Lupus**	3
• **Pielonefritis**	3
• **Poliquistosis**	1
• **HTA**	3
• **Perdida traumática o quirúrgica de riñón**	2
• **Otras**	9

Análisis estadístico

Los datos clínicos fueron analizados con la estadística descriptiva del SPSS versión 20.0 para Windows. El nivel de significación se predeterminó en p ≤ 0.05 para todas los análisis estadísticos utilizados. Se presentan los resultados con la media (derivación estándar) si se acepta la normalidad de distribución o por la mediana (mínima y máximo). Se utilizó un análisis descriptivo para mostrar los datos de las historias clínicas más relevantes. El test de Shapiro Wilk se utilizó para ver la distribución de normalidad de las pruebas. Se ha empleado la prueba no paramétrica de Wilcoxon de muestras relacionadas para comparar las mediciones realizadas al inicio y al final del estudio cuando la muestra no se distribuía de forma normal, y la prueba t de Student para muestras pareadas en caso de distribución normal.

Resultados

En la **Tabla 1** podemos observar los datos descriptivos de las historias clínicas de la muestra más relevantes. La muestra analizada está compuesta por un total de 43 participantes de los cuales 28 eran hombres y 15 eran mujeres. La edad media de esta población es de 61.3 ± 14.7 años. La mediana de los meses que los pacientes llevan en hemodiálisis es de 49 meses siendo el valor mínimo de 18 meses y el valor máximo de 382 meses. La etiología más común de esta muestra era la glomerulonefritis (10 pacientes) seguida de la Diabetes Mellitus (9 pacientes).

En la **Tabla 2** se describen los resultados de las pruebas realizadas en este estudio tanto al inicio como al final, representadas tanto con la media (DE) y la mediana (mínima-máximo).

El número de participantes disminuye en alguna de las pruebas. El motivo de éstas pérdidas son, la mayoría por fatiga u otros problemas de salud, a la hora de realizar las pruebas.

Como podemos observar en esta tabla, la mayoría de las pruebas de capacidad funcional que se completaron no muestran resultado significativos. Tres de las pruebas mejoran, de manera inesperada, significativamente: el STS 10 mejoró de 28.7 (10.6 – 60 segundos) a 25.5 (1.0 - 48.6 segundos); la dinamometría de la mano derecha incrementó de 25.7 (12.8) kg a 27.5 (14.5) kg; la dinamometría de la mano izquierda de 21.9 (12.4) kg a 24.6 (14.0) kg. Otras medidas no obtuvieron un deterioro significativo: SPPB, STS 60, elevación del talón izquierdo; 6MWT.

Respecto a los sujetos que abandonaron el estudio, la mitad tenían problemas serios de salud o fallecieron.

Tabla 2. Análisis estadístico que compara los resultados del inicio y el final del estudio.

Test	N		Pre		Post		p
	Pre	Post	X (DE)	Mediana (min-max)	X(DE)	Mediana (min-max)	
SPPB* (0-12 puntos)	42	42	10.02 (3.03)	12 (4-12)	10 (2.89)	11.50 (2-12)	0.0723
Equilibrio monopodal (máximo 30 segundos)	43	42	10.25 (11.89)	3.14 (0-30)	12.57 (14.24)	6.31 (0-30)	0.076
TUG* (segundos)	43	43	9.30 (4.01)	8.12 (0-21.66)	9.15 (4.69)	8.16 (0-25.84)	0.134
STS 10* (segundos)	43	39	28.7 (12.64)	24.57 (10.63-60)	25.5 (11.31)	26.53 (1.0-48.6)	0.042
STS 60* (repeticiones)	43	39	21.27 (9.05)	21 (2-48)	19.32 (9.4)	20 (0-37)	0.224
Dinamometría Derecha (kg)	43	43	25.68 (12.84)	28(0-62)	27.45 (14.55)	30 (0-66)	0.017
Dinamometría Izquierda (kg)	43	43	21.90 (12.39)	22 (1-58)	24.55 (14.01)	28 (0-65)	0.015
Elevación talón Derecho (repeticiones)	43	36	17.33 (10.10)	25 (0-25)	17.69 (9.74)	25 (0-25)	0.909
Elevación talón Izquierdo (repeticiones)	43	36	16.05 (10.19)	22 (0-25)	16.81 (9.36)	19.5 (0-25)	0.306
6MWT *(metros)	42	34	390.94 (131.42)	396 (84-678)	383.63 (141.78)	384 (96-706)	0.657

Discusión y conclusión

La mayoría de los estudios de pacientes renales investigan cómo mejorar la calidad de vida relacionada con la salud de la población que sufre insuficiencia renal crónica con programas de ejercicio. Sin embargo, aún habiendo sido demostrada la eficacia del aumento de actividad física en este tipo de sujetos, son pocas las unidades de diálisis que ofrecen programas de ejercicios a sus pacientes. Y, como se ha descrito en diversos estudios, las personas con insuficiencia renal crónica en tratamiento de hemodiálisis se caracterizan por sufrir alteraciones en su sistema músculo-esquelético, como es la pérdida de fuerza y disminución de la masa muscular[4,5,6], ,entre otro tipo de problemas, como alteraciones en el sistema cardiovascular y psicológicos. Lo que se ha intentado hacer en este estudio es describir cómo va disminuyendo el sistema músculo-esquelético en una población de pacientes que están en tratamiento de hemodiálisis desde hace años, y que la mayoría de ellos son personas sedentarias, en un periodo de tiempo de 6 meses. Se trata de una muestra de pacientes en hemodiálisis limitada y relativamente joven con un buen estado físico de salud. Llama la atención que, en ninguna de las pruebas de capacidad funcional que se ha realizado, se observa un deterioro significativo después de 6 meses. Incluso se ha visto una mejora en tres de las pruebas: en el STS-10 y dinamometría de mano derecha e izquierda. Los sujetos que no completaron los test eran personas con edad avanzada, que, después de 6 meses desde que comenzó el estudio, presentaban problemas serios de salud (problemas cardiacos e ingresos repetidos), lo que les impedía completar todas los test de capacidad funcional, además de ser los que peor condición física presentaban con respecto al resto de la muestra. Esto podría ser una de las causas por la que no se ha visto reflejada en la estadística el deterioro de capacidad funcional descrito por otros autores.[7,10,15]. Otras de las causas posibles de estos resultados puede ser la alta variabilidad en cuanto a la edad de la muestra. El sujeto de menor edad tenía 24 años y el de mayor edad 78 años. Cabe pensar que sujetos jóvenes van a tener mejor condición física y una vida más activa que las personas de edad avanzada. Al tratarse de una muestra relativamente joven podemos pensar que la mayoría de ellos son personas con una mejor condición física que las personas de mayor edad.

La principal limitación de este estudio es el pequeño tamaño de la muestra. Otra de las limitaciones que podemos haber encontrado es que la mayoría de los sujetos que participaron en el estudio son sujetos relativamente jóvenes que tienen una buena condición física, sin poder contar con las personas de edad avanzada que se encontraban en las unidades de diálisis. A pesar de estas limitaciones, debemos concienciar tanto a los profesionales sanitarios como a los propios pacientes la importancia de realizar un seguimiento de capacidad funcional ya que, como se ha descrito, a medida que los pacientes siguen con su tratamiento de hemodiálisis, se va produciendo un deterioro funcional entre otros, lo cual les produce tener una disminución de condición física y por ello de su calidad de vida relacionada con la salud.

Futuros estudios deberían incluir un mayor número de pacientes representativos a una muestra de pacientes con insuficiencia renal crónica y ampliar el periodo observacional.

En resumen, se recomienda a los centros de hemodiálisis realizar un seguimiento de capacidad funcional anualmente, ya que con un periodo de seis meses no se encuentran cambios significativos.

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ANEXOS

ESCALA DE ESFUERZO PERCIBIDO (EEP) **¿Cómo nota el ejercicio?**	
6	-
7	Muy, muy suave
8	-
9	Muy suave
10	-
11	Ligero
12	-
13	Algo duro
14	-
15	Duro
16	-
17	Muy duro
18	-
19	Muy, muy duro
20	Máximo esfuerzo percibido

Figura 1. Escala de Esfuerzo Percibido. (EEP)

APPENDIX 8. PAPER 2

ORIGINAL

Comparación de un programa de ejercicio intradiálisis frente a ejercicio domiciliario sobre capacidad física funcional y nivel de actividad física

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Resumen

Introducción: El ejercicio durante la hemodiálisis es beneficioso, aunque son pocas las unidades de hemodiálisis que ofrecen un programa de ejercicio adaptado a estos pacientes. Por ello es necesario encontrar alternativas más económicas para realizar ejercicio. El objetivo es comparar los efectos de un programa de ejercicio intradiálisis frente a ejercicio domiciliario, sobre la adherencia al programa, la capacidad física funcional y el nivel de actividad física.

Métodos: 17 pacientes en hemodiálisis de un centro de Valencia fueron aleatorizados dividiéndoles en un grupo de ejercicio intradiálisis (n=9) y un grupo domiciliario (n=8). Ambos programas incluían ejercicio aeróbico y de fuerza durante 4 meses. Se valoró una amplia batería de pruebas funcionales (*Short Physical Performance Battery*, equilibrio monopodal, *Timed Up and Go, Sit To Stand to sit test* 10 y 60, dinamometría de mano, fuerza de tríceps, 6 minutos marcha) y dos cuestionarios de nivel de actividad física (*Human Activity Profile* y *Physical Activity Scale for Elderly*).

Resultados: 2 pacientes del grupo intradiálisis y 5 pacientes de ejercicio domiciliario finalizaron el programa y fueron analizados. Se observó un efecto significativo del factor tiempo en el caso del *Human Activity Profile* (P<.017). En las pruebas funcionales no se encontró ninguna diferencia significativa. En cuanto a la adherencia al ejercicio los pacientes del grupo intradiálisis cumplieron el 92.7% y el grupo domiciliario el 68.7% del total de las sesiones.

Conclusiones: En ambos grupos se observa un aumento del nivel de actividad física. Sin embargo, es necesario modificar factores, tanto en el personal sanitario como en los propios pacientes, para conseguir mayor adherencia a los programas de ejercicio.

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PALABRAS CLAVE
- EJERCICIO INTRADIÁLISIS
- HOME BASED
- INSUFICIENCIA RENAL CRÓNICA
- ACTIVIDAD FÍSICA

Comparison of intradialysis exercise program versus home exercise on functional capacity and physical activity level

Abstract

Introduction: Although exercise training of patients undergoing hemodialysis is generally associated with positive outcomes, few hemodialysis units routinely offer intradialytic exercise therapy. This is often related to financial cost and/or staff limitations. Home-based. The aim of this study was to compare the effects of intradialytic versus home based exercise regarding adherence, functional capacity and physical activity level.

Methods: 17 participants from hemodialysis unit from Valencia were randomized to either intradialytic exercise (n=9,) or home based exercise (n=8). Both programs consisted of a combination of strength training and aerobic exercise during 4 months. We assess functional capacity with different test (Short Physical Performance Battery, one leg stand, Timed Up and Go, Sit To Stand test 10 and 60,handgrip, one leg heel rise, 6 minutes walking test) and two questionnaires to asses physical activity level (Human Activity Profile and Physical Activity Scale for Elderly).

Outcomes: 2 participant from the intradialysis exercise and 5 participants from de home based exercise were analysed. We observed a significant time effect in the Human Activity Profile (P<.017). In the functional capacity test there was not a significant difference. The subjects from the intradilysis exercise completed the 92.7% and the home based group the 68.7% of the total of the sessions.

Conclusions: In both groups was an increment of the physical activity. Nevertheless, it is necessary to modify some factors, both in health professionals and patients, to achieve higher.

KEYWORDS
- INTRADIALYSIS EXERCISES
- HOME BASED
- CHRONIC KIDNEY DISEASE
- PHYSICAL ACTIVITY

Introducción

Los pacientes con Insuficiencia Renal Crónica (IRC) en estadio terminal, pueden ser sometidos a hemodiálisis (HD) como tratamiento renal sustitutivo, el cual suple las principales funciones del riñón.

A medida que van pasando los años, la HD va afectando a los diferentes sistemas del organismo, entre los que destacan el sistema cardiovascular[1,2] y el músculo-esquelético[1,3,4,5], aunque estos pacientes también sufren alteraciones psicosociales. Es común encontrar en los pacientes en HD un bajo nivel de calidad de vida relacionado con la salud, asociado frecuentemente a la presencia de ansiedad y depresión[6,7,8,9].

Esto no es solo debido a la HD. Estos pacientes tienen un nivel de actividad significativamente inferior al que presentan sus homólogos sanos[10]. De hecho hay estudios que demuestran que la mayoría de los pacientes que están en este tipo de tratamiento tienen una vida sedentaria[11]. Es por ello, que esta población presenta una disminución de la capacidad funcional[12,13] que provoca una dependencia en las actividades de la vida diaria, discapacidad, así como un incremento del riesgo de hospitalización y mortalidad[14].

El ejercicio físico se viene utilizando como herramienta terapéutica en estos pacientes desde principios de los años 80[15].Hay tres tipos de modalidades para los programas de ejercicio terapéutico: ejercicio en casa, ejercicio supervisado en días de no diálisis o ejercicio durante la sesión de HD. En el ejercicio intradiálisis es donde mejores resultados se ha obtenido por el control de constantes del paciente durante el ejercicio y por ser la modalidad que más sesiones de seguimiento consigue[16]. La literatura dice que haciendo una combinación de ejercicio aeróbico y de resistencia muscular los pacientes obtienen mejores resultados[17] .Sin embargo, a día de hoy, son muy pocas las unidades que tienen implantado el ejercicio como una rutina durante las sesiones de HD[18], y una posible causa puede ser el coste económico que esto supone. Es por ello, que la implantación de un programa de ejercicio domiciliario podría suponer una posibilidad menos costosa para intentar conseguir mejorar la capacidad funcional de estos pacientes.

Por tanto, el objetivo principal de este estudio fue comparar los efectos de un programa de ejercicio intradiálisis frente a ejercicio domiciliario, sobre la adherencia al programa, la capacidad física funcional y el nivel de actividad física.

Material y métodos

Sujetos

Se incluyeron a diecisiete pacientes con insuficiencia renal crónica en estadio terminal de la unidad de diálisis al Hospital Virgen del Consuelo de Valencia (España) para participar en el estudio entre octubre de 2014 y enero de 2015. El estudio fue aprobado por el Comité de Ética y los participantes firmaron el consentimiento informado. La investigación se realizó dentro de las pautas marcadas por la Declaración de Helsinki de 1975.

Los criterios de inclusión fueron: estar al menos 3 meses en tratamiento de hemodiálisis y encontrarse estable médicamente. Los criterios de exclusión fueron: (1) Infarto de miocardio en las 6 semanas previas (2) angina inestable al ejercicio o en reposo (3) amputación de miembros inferiores por encima de rodilla sin prótesis (4) enfermedad vascular cerebral (ictus, isquemias transitorias) (5) alteraciones músculo-esqueléticas o respiratorias que empeoren con el ejercicio (6) imposibilidad de realizar las pruebas funcionales.

Se dividieron a los sujetos en dos grupos de manera aleatorizada: un grupo de ejercicio intradiálisis (GI) (n=9) y otro grupo de ejercicio domiciliario (GD) (n=8) que voluntariamente quisieron realizar el ejercicio.

Se tomaron los siguientes datos clínicos al inicio del estudio: edad, peso seco, índice de masa corporal, tiempo en HD, horas de HD a la semana.

La capacidad física funcional y el nivel de actividad física se midieron al inicio y al final del programa.

Capacidad física funcional

Las pruebas funcionales encaminadas a evaluar la condición física de los pacientes fueron el *Short Physical Performance Battery* (SPPB), el equilibrio monopodal, el *Timed up and go* (TUG), el Sit to stand to sit test 10 y 60 (STS 10 y STS 60), la dinamometría de mano, la fuerza de tríceps sural, y el 6 minutos marcha (6MWT).

La prueba Short Physical Performance Battery (SPPB) se registró el primer día antes de la sesión de HD. Consta de tres pruebas de equilibrio, con los pies juntos, en posición de semitándem y en tándem, y se valora si el sujeto puede mantener cada una de estas posiciones hasta un máximo de 10 segundos. La valoración del equilibrio va de 0 a 4 puntos. Incluye también una prueba de velocidad de la marcha en 4 metros a velocidad habitual. Se realizaron dos intentos cronometrados y se registró el mejor de ellos, de forma que, según los segundos empleados, se asignó una puntuación de 1 a 4. Se valoró también la prueba STS-5, que consiste en medir el tiempo empleado en levantarse y sentarse de la silla 5 veces con los brazos cruzados en el pecho, deteniendo el cronómetro cuando el paciente alcanzaba la posición de pie en la repetición 5. Según el tiempo empleado se asignó una puntuación de 0 a 4 puntos. Por lo tanto, la puntuación del SPPB va de 1 a 12 puntos[19].

Se valoró también el equilibrio estático monopodal antes de la primera sesión semanal de HD, pidiendo a los sujetos que levantasen una pierna flexionándola de forma que se pusieses a la pata coja, con la pierna que se encontrasen más seguros. Se les pidió que aguantasen el equilibrio el mayor tiempo posible. El fisioterapeuta anotó el tiempo que el paciente aguantaba en posición de apoyo monopodal. El sujeto podía mover los brazos y flexionar la rodilla si lo necesitaba para mantener el equilibrio. El tiempo finalizaba cuando el sujeto usaba sus brazos para apoyarse, utilizaba el pie elevado para apoyarse en el suelo, cuando el pie apoyado se movía para mantener el equilibrio o cuando el tiempo llegaba a los 45 segundos. Se repitió el procedimiento 3 veces y se registró el mejor tiempo[20].

La prueba "Timed Up and Go" (TUG)[21,22], también se realizó previamente a la primera sesión de hemodiálisis. Desde una silla el paciente se tenía que levantar, caminar 3 metros y volver a la posición inicial. Se repitió el procedimiento 3 veces y se registró el mejor tiempo.

La prueba de dinamometría de mano se realizó con el Dinamómetro JAMAR previamente al segundo día de la sesión semanal de HD. Según varios estudios en pacientes en diálisis, existe una correlación entre la fuerza de prensión de la mano con su estado de salud[23,24]. Los sujetos sentaban en una silla, con los pies apoyados en el suelo y las rodillas flexionadas 90º. El hombro del brazo que se estaba registrando permanecía en rotación neutra, con el codo en flexión de 90º apoyado en la mesa, muñeca y antebrazo semipronados (0-30º) y una desviación cubital entre 0 y 15º. Se realizaron 3 repeticiones consecutivas, con un descanso de 15 segundos entre ellas, en cada uno de los miembros superiores, comenzando por el brazo dominante. Se dio ánimo verbal en las repeticiones y se registró la de valor máximo.

El segundo día de la sesión semanal de hemodiálisis también se realizaron las pruebas del STS 10 y STS 60, tal y como describen Cüska y McCarty[25]. La primera consiste en medir los segundos que necesita el paciente para levantarse y volver a sentarse 10 veces consecutivas lo más rápido posible, desde una posición de sentado y con los brazos cruzados en el pecho. Tras realizar las 10 repeticiones se registró el tiempo que había necesitado para realizar la prueba, así como el grado de dificultad en la Escala de Esfuerzo Percibido (EEP) **(Figura 1).**

ESCALA DE ESFUERZO PERCIBIDO (EEP) ¿Cómo nota el ejercicio?	
6	-
7	Muy, muy suave
8	-
9	Muy suave
10	-
11	Ligero
12	-
13	Algo duro
14	-
15	Duro
16	-
17	Muy duro
18	-
19	Muy, muy duro
20	Máximo esfuerzo percibido

Figura 1. Escala de Esfuerzo Percibido (EEP).

A continuación, tras un periodo de recuperación de 3 minutos como mínimo, se realizó el STS 60. Se explicó al paciente que la prueba consistía en realizar el máximo número de repeticiones de levantarse y volver a sentarse en un tiempo de 60 segundos. Tras la realización de la prueba se registraron las repeticiones y se anotó el grado de dificultad de la prueba según la EEP.

La prueba de la fuerza del tríceps sural o prueba de elevación de talón monopodal, se realizó también inmediatamente antes de la segunda sesión semanal de HD[26,27,28]. Los pacientes debían de estar descalzos. El ritmo de elevación del talón se marcó mediante un metrónomo. Antes de iniciar la prueba se pidió al paciente que mantuviese el equilibrio sobre una sola pierna, con un apoyo ligero de las puntas de los dedos en la pared, con los brazos separados del tronco y evitando que trasladasen el peso a través de los brazos a la pared, mientras el pie contralateral se situó ligeramente elevado del suelo. Se permitió un intento de elevación con el pie izquierdo, tras el cual se procedió a valorar la elevación del talón derecho. Se les pidió que elevaran el talón todo lo que pudieses al ritmo del metrónomo hasta que no pudieses elevar el talón por fatiga muscular. Si el sujeto compensaba con los brazos contra la pared o flexionaba la rodilla terminaba la prueba. También finalizaba si alcanzaba las 25 repeticiones, pues se ha establecido que estas son las repeticiones que de media se encuentran en la población sana[26,27]. Se anotó el número de repeticiones por cada pierna así como el grado de dificultad según la EEP.

La prueba de 6 minutos marcha (6MWT) se realizó previamente a la tercera sesión semanal de hemodiálisis, en el pasillo de la unidad. En el momento previo a la realización de la prueba se registró, mediante un esfigmomanómetro digital, la tensión arterial y la frecuencia cardiaca en el brazo sin fístula. A continuación se le indicó al paciente que durante 6 minutos, debía recorrer la máxima distancia señalada por unas marcas en el suelo, girando sin parar cada vez que recorría 20 metros. La orden dada al paciente fue la siguiente: «tiene que intentar recorrer la máxima distancia posible en este pasillo de 20 metros, andando lo más rápido que pueda sin llegar a correr». Se permitió realizar el test con ayudas para la deambulación si el paciente las utilizaba en su vida diaria o con la asistencia de otra persona, o parar y reiniciar la marcha en caso de necesitar un descanso durante el test. Se registró la distancia recorrida y se pidió al paciente que describiera en la EEP cuál había sido el grado de dificultad de la prueba[29].

Nivel de actividad física

La valoración del nivel de actividad física de los sujetos se realizó mediante dos cuestionarios en la versión en español, el *Physical Activity Scale for the Elderly* (PASE) y el cuestionario *Human Activity Profile* (HAP). Ambos cuestionarios han sido validados en la población con enfermedad renal[8]. El PASE fue diseñado para valorar la actividad realizada la semana previa según la respuesta de los sujetos a una serie de cuestiones sobre el tiempo empleado en actividades cotidianas. El total de la puntuación se calcula como la suma de tiempo en cada actividad multiplicado por la carga de la actividad[8].

El HAP es un cuestionario de 94 ítems, que valora la participación en actividades que requieren diferente cantidad de aporte energético. Los sujetos deben asignar cada actividad en una de las categorías: (1) puedo realizar esta actividad, (2) he dejado de realizar esta actividad) y (3) nunca he realizado esta actividad. Se valora tanto el máximo nivel de actividad como la puntuación de actividad ajustada, que se considera un estimador más estable de la actividad cotidiana del sujeto[30]. La puntuación de actividad máxima (MAS) es el número de ítems clasificados como el máximo consumo de oxígeno requerido que el sujeto puede realizar. La puntuación de actividad ajustada (AAS) es el resultado de restar al MAS y el número de actividades que el sujeto ha dejado de realizar, dando una mejor estimación del rango de actividades que puede realizar y la presencia de incapacidad. Por ejemplo, un sujeto cuya actividad más vigorosa que puede seguir realizando es la de "subir 36 peldaños" (ítem número 60) tendrá un MAS de 60. Si el individuo ya no realiza 6 actividades que requieren menos gasto energético que subir 36 peldaños de una escalera, su AAS será 54. Así pues, la puntuación del HAP representa un rango de actividades que una persona puede realizar en lugar de la actividad real realizada durante un periodo de tiempo determinado. El HAP ha mostrado ser fiable para valorar la actividad física en sujetos en HD[8,31].

Intervención de ejercicio de fuerza-resistencia intradiálisis

La intervención tuvo una duración de 4 meses, y fue realizada durante las 2 primeras horas de hemodiálisis, los tres días semanales que el paciente acudió a tratamiento. El programa de ejercicio consistió en la realización de ejercicios isotónicos e isométricos de resistencia progresiva con objeto de potenciar la musculatura de los miembros inferiores. Cada sesión de ejercicio se estructuró en un calentamiento, una parte principal y una vuelta a la calma. La sesión de ejercicio comenzaba y terminaba con unos 5 minutos de ejercicios de estiramientos de tríceps sural, isquiotibiales y movilizaciones de cadera. La parte principal de trabajo consistía en una serie de ejercicios de potenciación muscular, adaptado a la posición en que el paciente realizaba la HD. El primer ejercicio consistía en una extensión de la rodilla desde los 90º a los 0º con lastres en el tobillo, con un ritmo de contracción controlado mediante un metrónomo digital y vuelta a la posición inicial (2 segundos de contracción concéntrica 2 segundos de contracción isométrica y cuatro segundos de contracción isotónica excéntrica, sin pausa entre repeticiones). La carga se determinó con la prueba de 10 RM (repetición máxima) y de forma que percibiera un esfuerzo de entre 12 y 15 EEP.

El segundo ejercicio consistía en realizar una dorsiflexión y plantiflexion de tobillo con goma elástica. La banda elástica se colocaba a nivel de las cabezas de los metatarsianos. El ritmo de contracción estaba controlado por un metrónomo digital y consistía en realizar contracción excéntrica de 1 segundo (dorsiflexión) y contracción concéntrica de 2 segundos (plantiflexión). Se aumentaba la resistencia poniendo otra banda elástica. El paciente tenía que realizar 15 repeticiones.

El tercer ejercicio consistió en realizar una triple extensión de tobillo, rodilla y cadera contra una banda elástica, de forma que se estandarizaba la posición de partida en 90º de flexión de cadera, rodilla y tobillo. La banda elástica se colocaba a nivel de las cabezas metatarsianas y se pedía una triple extensión de 2 segundos de contracción concéntrica y 2 segundos de contracción excéntrica. La progresión en resistencia se consigue colocando una segunda banda elástica.

El cuarto ejercicio consistía en realizar isométricos de los aductores colocando una pelota entre las rodillas del pacientes Se les pedía que hicieran fuerza con las piernas, apretando el balón, a la vez que apretaban también los glúteos. El paciente tenía que aguantar cada contracción durante 6 segundos en tiempo espiratorio. El paciente realizó 15 repeticiones en cada una de las sesiones de ejercicio.

El quinto ejercicio consistió en un isométrico de isquiotibiales y el paciente se tenía que colocar la pelota entre el bajo del sillón y detrás de los talones. Se les pedía que hicieran fuerza con los talones hacia atrás en tiempo espiratorio. Tenían que aguantar la contracción durante 6 segundos. El paciente realizaba 15 repeticiones en cada una de las sesiones.

Durante todos los ejercicios se aseguró que la respiración fuera correcta, realizando los esfuerzos en espiración y evitando la maniobra de Valsalva.

Una vez finalizados los ejercicios de fuerza el paciente tenía que realizar bicicleta. La resistencia de la bicicleta se subía hasta que el paciente percibiera un esfuerzo de entre 12 y 15 EEP. El tiempo de la bicicleta se iba incrementando progresivamente durante el programa. Así es que el paciente comenzó pedaleando 15 minutos y terminó pedaleando 45 minutos.

Se realizó un seguimiento de los días que los participantes realizaban el ejercicio con un diario.

Intervención de ejercicio de fuerza-resistencia domiciliaria

El paciente tenía que realizar ejercicio en casa 3 días semana los días que a él le vinieran bien, ya fueran días de diálisis como días de no diálisis. Al comienzo, y durante tres sesiones, un fisioterapeuta le dio indicaciones sobre intensidad (se tenían que monitorizar la frecuencia cardiaca, la tensión arterial y siguiendo la EEP), frecuencia (mínimo 3 veces por semana) y modalidad de ejercicio (combinación de fuerza y aeróbico) que tenían que realizar. Se les entregó un dossier donde tenían toda la información necesaria para que realizaran el ejercicio en casa de forma independiente (detalle de los ejercicios con fotografías, repeticiones y series), así como un diario de registro de actividad.

Los ejercicios de los que constaba este programa eran similares a los realizados por el grupo intradiálisis. Se realizó un seguimiento por parte del fisioterapeuta cada vez que iba a la unidad de diálisis a realizar el ejercicio durante la diálisis, de modo que durante los dos primeros meses les preguntaba una vez por semana y posteriormente 1 vez al semana. Si los participantes tenían cualquier duda se podían poner en contacto con el fisioterapeuta, para aclarar dudas o resolver cualquier problema que existiera con el programa, tanto por contacto telefónico como en la misma unidad de diálisis.

Análisis estadístico

Dado el tamaño reducido de la muestra, los datos obtenidos no se ajustan a una distribución normal (test de Kolmogorov Smirnov, asimetría y curtosis). Se utilizó la prueba no paramétrica U de Mann-Whitney para comprobar si había diferencia entre los grupos en características iniciales de los grupos. Se analizó el efecto de los programas de ejercicio mediante un test ANOVA mixto, con el factor tiempo intra-grupo y el grupo de intervención como factor entre grupos. Los datos se presentan como mediana, mínimo y máximo, o como media y desviación estándar. El análisis estadístico se realizó mediante el programa SPSS 20.0 para Windows (SPSS Inc., Chicago, Ill) tomando como significativos valores de p<0.05.

Resultados

En el GI había 4 hombres y 5 mujeres, mientras que en el GD estaba formado por 4 hombres y 4 mujeres.

Del GI se produjeron 7 bajas a lo largo del estudio: una persona le tocó el GI y quería realizar ejercicio a domicilio; dos personas abandonaron por problemas cardíacos y/o de tensión arterial durante el ejercicio; una persona abandonó por problemas articulares; una persona abandonó por fractura de tibia; una persona abandonó por ingreso prolongado en el hospital; una persona falleció. En el GD se produjeron 3 bajas: una persona abandonó porque no quería realizar ejercicio a domicilio, otra persona abandonó por fractura de tibia y otra persona fue trasplantada.

La **tabla 1** muestra los datos de la historia clínica de los pacientes. Se puede observar que no hay diferencias significativas entre los grupos en términos de edad o índice de masa corporal.

Tabla 1. Datos historia clínica.

Variable	Grupo Intradiálisis n= 2 X (DE)	Grupo Domiciliario n= 5 X(DE)	P
Edad	70.50 (9.192)	67 (7.649)	0.845
Índice de Masa Corporal (kg/m^2)	29.30 (5.05)	19.83 (11.45)	0.121

Las causas de enfermedad renal fueron: glomerulonefritis (2), diabetes mellitus (2), nefroangioesclerosis (2) y otros motivos (1).

La **tabla 2** muestra los valores de las pruebas funcionales de los pacientes del grupo intradiálisis y grupo domiciliario antes y después de la realización del programa. No se observaron diferencias significativas en ninguna de las pruebas de capacidad funcional. Sin embargo podemos observar que el grupo intradiálisis mejora en alguna pruebas de capacidad funcional como son el equilibrio monopodal (mediana pre 5.3 segundos, mediana post 10.9 segundos), STS 60 (mediana pre 19.5 repeticiones, mediana post 22.5 repeticiones). Se puede observar también que el valor mínimo mejora también en algunas pruebas funcionales como son en. el valor mínimo en la Dinamometría de la mano derecha que pasó de 20.5 kg a 25 kg. Y por último en la prueba del 6MWT el valor mínimo de los metros recorridos fue 366 y al terminar el programa de ejercicio aumentó a 414 metros.

En el grupo domiciliario podemos observar que el valor mínimo de la prueba SPPB pasa de 8 puntos a 11 puntos. En la prueba STS-60 hay una disminución del número de repeticiones en los valores máximos (pre max 41; post max 25). En la dinamometría de mano izquierda podemos observar un ligero aumento de fuerza. Y por último en la prueba de Triceps Sural de la pierna izquierda se observa un aumento de la mediana pre (13 repeticiones) con respecto de la mediana post (25 repeticiones).

En la **Tabla 3** se describen los resultados de los cuestionarios de nivel de actividad que los pacientes tuvieron que rellenar antes y después del programa de ejercicios. Se puede observar que únicamente en el cuestionario HAP hay diferencias significativas en el factor tiempo (P<.017) donde la mediana de los pacientes del GI tenían una puntuación pre de 48.5 (min44 - max 53) y post de 62 (min 8 - max 66); mientras en el HB obtuvieron una puntuación pre de 7 (min 2 - max 54) y post de 17.5 (min 13 y - max 86).

En cuanto a la adherencia a los programas de ejercicio los pacientes del GI cumplieron el 92.7% del total de las sesiones, mientras que el grupo HB cumplió el 68.7% del total de las sesiones.

Discusión y conclusión

Los resultados de este estudio indican que el nivel de actividad con un programa de ejercicio de 4 meses aumenta. Se ha observado una diferencia en cuanto el nivel de actividad física en el cuestionario HAP en el factor tiempo en la puntuación de actividad ajustada (ASS), aumentando en ambos grupos (en el GI la mediana del HAP AAS pre fue 48.5 puntos con un mínimo de 44 y un máximo de 53 puntos y el post la mediana fue de 62 puntos con un mínimo de 58 y un máximo de 66; mientras que en el grupo HB la mediana pre del HAP AAS fue de 7 con un mínimo de 2 y un máximo de 54 puntos y la post de 17.5 puntos con un mínimo de 13 y un máximo de 86). Este cuestionario se ha relacionado con el nivel de actividad de las personas con IRC y proporciona una estimación más estable de las actividades diarias de la persona. Esto significa que pasan de ser considerados personas inactivas a persona moderada-

Tabla 2. Pruebas de capacidad funcional.

VARIABLES	Hemodiálisis	Domicilio	n	F tiempo *grupo	p[a]	F tiempo	p[b]
SPPB (0-12 puntos)							
Pre Mediana(Min-Max)	11 (10-12)	10 (8-12)					
Post Mediana (Min-Max)	11,5 (11-12)	11 (11-12)					
			7	0.660	0.453	3.895	0.105
Equilibrio Monopodal (45 segundos)							
Pre Mediana(Min-Max)	5.33 (4.07-6.60)	6.53 (1-45)					
Post Mediana (Min-Max)	10.85 (1.96-19.75)	4.18 (1.59-45)					
			7	0.688	0.445	0.575	0.483
TUG (segundos)							
Pre Mediana (Min-Max)	7.75 (7.25-8.25)	8.78(6.19-11.91)					
Post Mediana (Min-Max)	7.43 (7.06-7.81)	8.34 (7.03-11.09)					
			7	0.037	0.855	0.931	0.379
STS 10 (segundos)							
Pre Mediana (Min-Max)	22.51(19.78-25.25)	17.47(14.57-22.82)					
Post Mediana (Min-Max)	22.68(21.06-24.30)	21.34 (16.81-22.31)					
			7	0.307	0.603	0.454	0.531
STS 60 (repeticiones)							
Pre Mediana (Min-Max)	19.5 (19-20)	22 (16-41)					
Post Mediana (Min-Max)	22.5 (22-23)	22 (18-25)					
			7	0.574	0.483	0.001	0.980
Dinamometria mano Dcha (Kg)							
Pre Mediana (Min-Max)	26.25 (20.5-32)	34(13-40)					
Post Mediana (Min-Max)	29.5(25-34)	30(16-39)					
			7	1.321	0.302	1.321	0.302
Dinamometria mano Izq (Kg)							
Pre Mediana (Min-Max)	27 (26-28)	24(10-32)					
Post Mediana (Min-Max)	27 (26-28)	26 (14-34)					
			7	3.673	0.113	3.673	0.113
Triceps Sural Dch (repeticiones)							
Pre Mediana (Min-Max)	23.5 (22-25)	20(3-25)					
Post Mediana (Min-Max)	23.5(22-25)	15 (0-25)					
			7	0.006	0.941	0.006	0.941
Triceps Sural izq (repeticiones)							
Pre Mediana (Min-Max)	19 (13-25)	13 (0-25)					
Post Mediana (Min-Max)	25 (25-25)	25 (0-25)					
			7	0.220	0.659	3.516	0.120
6MWT (metros)							
Pre Mediana (Min-Max)	413 (366-460)	387 (320-525)					
Post Mediana (Min-Max)	439 (414-464)	380 (348-522)					
			7	0.889	0.389	2.594	0.168

mente activas según la clasificación que se da para el HAP[8,31]. Como se puede ver en los resultados hay una diferencia significativa en ambos grupos pero no entre grupos, por tanto, se puede realizar un programa de ejercicio domiciliario, el cuál es más económico, para aumentar la actividad de esta población. Aunque este hallazgo se debería confirmar con estudios con un número de muestra mayor.

El porcentaje de nivel de adherencia entre el grupo de ejercicio durante la hemodiálisis con respecto al grupo domiciliario vemos que el primero ha realizado mayor número de sesiones que el grupo que tenía que realizar el ejercicio en casa. Preguntando de manera subjetiva a los participantes por las barreras que habían encontrado para hacer el ejercicio, nos comentaron que al no tener a nadie con quien realizar el ejercicio les costaba

Tabla 3. Nivel de actividad funcional.

VARIABLES	Hemodiálisis	Domicilio	n	F tiempo *grupo	p^a	F tiempo	p^b
PASE (0-100)							
Pre Mediana (Min-Max)	35.6 (20.4-50.8)	51.5 (5-107.4)					
Post Mediana (Min-Max)	73.2 (47.8-98.6)	64.4 (58.6-128.5)					
			6	0.256	0.640	6.473	0.064
HAP MAS(puntuación)							
Pre Mediana (Min-Max)	67.5 (66-69)	48.5 (48-73)					
Post Mediana (Min-Max)	77 (75-79)	53.5 (52-90)					
			7	0.710	0.503	0.050	0.830
HAP AAS(puntuación)							
Pre Mediana (Min-Max)	48.5(44-53)	7 (2-54)					
Post Mediana (Min-Max)	62 (58-66)	17.5 (13-86)					
			7	0.090	0.777	12.470	0.017

mucho más ponerse a hacerlo ya que siempre estaban ocupados con otras tareas y que no había nadie en sus casas que les insistiera. Estas barreras han sido descritas por otros artículos[32]. Para que hubiese una mayor adhesión al programa de ejercicio se les explicó cuáles eran los beneficios de realizar los ejercicios, lo cual también tenían descrito en el folleto que se les entregó. Se intentó acudir un día a su casa para explicarles el programa y así coincidir con algún familiar para que se involucraran, pero únicamente dos personas quisieron que acudiéramos a su domicilio. Se realizó un seguimiento donde se les preguntaba los días de diálisis si estaban haciendo el programa y se les insistía en los beneficios que obtendrían. En comparación con En el estudio de Tao et al 2015 donde se lleva a cabo también un programa de ejercicio domiciliario, las propias enfermeras realizaron una serie de estrategias de educación para que el paciente reforzara el ejercicio. Éstas se sentaban con cada paciente entre 15 y 30 minutos y les explicaban cuáles eran los beneficios de realizar el ejercicio, buscaron las posibles barreras que podían encontrar en casa e intentaban buscar una solución, llegaban a un consenso para marcarse unas metas y monitorizaban el ejercicio[33]. En este estudio también se hablaba tanto con el médico como con los familiares para hacer frente a las barreras. Sin embargo, los pacientes de este estudio que realizaron el programa a domicilio no querían que fuéramos a sus casas para hacer más partícipes a sus familiares. En futuros estudios se debería ampliar la muestra y se hacer más partícipes tanto los profesionales sanitarios de la propia unidad como a los propios pacientes y familiares. Se ha demostrado que el apoyo de los médicos y la gestión individualizada del programa hace que se contribuya al éxito de los programas domiciliarios[33].

El principal hallazgo que podemos encontrar en este artículo es que después de realizar una comparación en cuanto a la capacidad funcional con diferentes pruebas funcionales no encontramos ninguna diferencia significativa entre ambos grupos. Esto puede ser debido al reducido tamaño de la muestra que se ha utilizado y es posible que el programa de ejercicio, tanto el del grupo intradiálisis como en el del grupo domiciliario, no fueran los más acertados ya que la mejora en cuatro meses no es significativa en ningún grupo.

En el futuro, estudios controlados aleatorios deberían tener un tamaño muestral mayor al del presente estudio, donde se prevea la pérdida de sujetos debido a la alta comorbilidad. Ello conllevaría a clarificar si sería factible realizar un programa de ejercicio domiciliario donde los participantes tuvieran una mayor adherencia al programa de ejercicio, así como si las pruebas de capacidad funcional y los cuestionarios que miden el nivel de actividad tuviesen una diferencia significativa entre los resultados antes y después de un programa de ejercicio que combine fuerza muscular y ejercicio aeróbico y el efecto que produce sobre en la calidad de vida de este tipo de población.

Por otra parte, vemos qué efecto puede producir que un fisioterapeuta esté en una unidad de diálisis para que haya una mayor adherencia al programa de ejercicio y una mayor predisposición por parte del paciente a realizar el ejercicio. Aún así, habría que incentivar la participación de aquellos pacientes de mayor edad, dada la baja predisposición observada a realizar ejercicio.

A pesar de estar demostrado que el ejercicio durante la hemodiálisis tiene beneficios para los pacientes con IRC en su calidad de vida relacionada con la salud, las unidades de diálisis no tienen personal cualificado que monitorice programas de ejercicio en esta población. Es por ello que se puso en marcha este estudio, con el objetivo de ver el efecto de realizar ejercicio en el domicilio. Que tengamos constancia, es la primera vez que se aplica un programa de ejercicio en casa para pacientes con IRC en España. El incremento de la actividad física de los enfermos que están obligados tener este tipo de tratamiento y que supone un número elevado de horas en la posición de sedestación o en decúbito supino, puede ser un medio para así disminuir el deterioro musculo-esquelético en estos pacientes.

Podemos concluir que tanto el ejercicio durante la hemodiálisis como el ejercicio domiciliario resultan en un aumento del nivel de actividad física de los pacientes con insuficiencia renal crónica en tratamiento de hemodiálisis. Es por ello que consideremos necesario modificar factores, tanto en el personal sanitario que atiende a estos pacientes, como en los propios pacientes, para conseguir mayor adherencia a los programa de ejercicio.

Agradecimientos

Agradecer al Servicio de Nefrología del Hospital Virgen del Consuelo de Valencia su hospitalidad y colaboración para poder llevar a cabo este estudio, así como a todo el Departamento de Fisioterapia de la Universidad CEU Cardenal Herrera.

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APPENDIX 9. ABSTRACTS ACCEPTED IN CONGRESSES

45th EDTNA / ERCA International Conference in Valencia (Spain), presented as POSTER

45th EDTNA/ERCA
International Conference
September 17–20, 2016
Valencia, Spain

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Absolute and relative reliability for several functional tests in patients undergoing haemodialysis

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Background
Patients with Chronic Kidney Disease (CKD) are known to have decreased functional capacity that may be associated with low levels of physical activity and can lead to impairment in activities of daily living. We know relatively little about what constitutes a meaningful change in tests that are used to test the physical function of this cohort.

Objectives
The aims of this study were to assess the relative and the absolute reliability of the Short Physical Performance Battery (SPPB), one leg stance test (OSL) and Timed Up and Go (TUG); and to calculate the minimally detectable change (MDC) scores for these outcomes in CKD patients receiving haemodialysis (HD).

Methods
Twenty-nine CKD patients receiving HD therapy participated. Participants completed two testing sessions performed by the same examiner, 1 to 2 weeks apart, of the following tests: SPPB (n= 24), OSL (n= 24) and TUG (n=25).

Results
The intraclass correlation coefficients computed for the SPPB were 0.94(CI 95% 0.86 to 0.97), with TUG = 0.97(CI 95% 0.94 to 0.99), OSL = 0.71(CI 95% 0.44 to 0.86). The minimal detectable change (MDC) was calculated to be 1.6 points for the overall SPPB(CI 95% 1.1 to 2.4); 15.6 seconds to the OLS(CI 95% 10.7 to 21.7) and 2.4 seconds for the TUG test (CI 95% 1.5 to 3.5).

Conclusion/Application to practice
The SPPB and the TUG test were considered to offer acceptable reliability in this patient sample. The MDC data generated by these tests can be used to monitor "meaningful" change in activity of daily living-related functional capacity of these patients.

53rd Congress ERA-EDTA Vienna, presented as POSTER

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COMPARISON OF
INTRADIALYTIC VERSUS HOME-BASED EXERCISE PROGRAMMES ON PHYSICAL FUNCTION,
PHYSICAL LEVEL AND HEALTH RELATED QUALITY OF LIFE

Author Block: Lucía Ortega Pérez de Villar[1], Borja Pérez Domínguez[1], Javier Martínez Gramage[1], MªJesús Lidón Pérez[2], Sara Antolí García[1], Andrea Bono Sala[1], Francisco Palomo Peña[1], Pablo Molina Vila[2], Eva Segura Ortí[1], [1]CEU Cardenal Herrera University, Physical Therapy, Valencia, SPAIN, [2]Hospital Universitario Dr Peset, Nephrology, Valencia, SPAIN.

Abstract:
INTRODUCTION AND AIMS: Although exercise training of hemodialysis patients is associated with generally positive outcomes few haemodialysis units routinely offer intradialytic exercise therapy. The aim of this study was to compare the effects of 4 months intradialytic versus home-based exercise in haemodialysis patients regarding physical function, physical level, depression and health related quality of life.
METHODS: This study was a randomized controlled trial, and forty-six patients undergoing haemodialysis were randomized to either intradialytic exercise or home-based exercise. Both programmes consisted of a combination of strength training for lower limbs and aerobic exercises during 4 months. Physical function assessed by The Short Physical Performance Battery (SPPB); the Human Activity Profile (HAP) and the Physical Activity Scale for Elderly (PASE) assessed physical level. The quality of life related with health was measured by the Kidney Disease Quality of Life - 36 questionnaire (KDQoL-36). The ANOVA mixed model was used to assess data.
RESULTS: Thirteen subjects from the intradialytic group and ten from de home-based group did not complete the study. A total of twenty-three patients, 16 were males, completed the study and were analysed (Intradialytic group n= 11, age 65.9 (14.9) years old; home-based group n= 12, age 62.4 (12.2) years old). There was a significant time effect
for several variables: SPPB, HAP and PASE were significant (P=.013, P= .011, P= .001, respectively). The KDQoL-36 did not show significan.
CONCLUSIONS: Both groups results in an increased of physical function and physical level according with our results. However, it is necessary to modify attitudes towards exercise in both health professionals and patients undergoing haemodialysis to achieve higher participation in all the programmes.
:

Category (Complete): J7) Chronic Kidney Disease. Rehabilitation.
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047 INRS	**The NIH Stroke Scale Lacks Validity In Chronic Hemiparetic Stroke** Heather Peters, Susan White, Stephen Page
048 ICVR	**Serious Game Based Dysphonic Rehabilitation Tool** Zhihan Lu, Chantal Esteve, Javier Chirivella, Pablo Gagliardo
049 ICVR	**Hand and Foot In-Air Interaction for Hemiplegia** Zhihan Lu, Haibo Li
050 ICRAN	**CogniVis: 3D Visualization and Navigation Module of Brain Structures** Jorge García-Novoa, Borja Rodríguez-Vila, Patricia Sánchez-González, Marta Luna, José María Tormos, Enrique J. Gómez
051 INRS	**The Cognitive Function in the Acute Stage Impacts on Post-stroke Functional Recovery** Jihong Park, Gangpyo Lee, Shi-Uk Lee, Se Hee Jung
052 ICVR	**Designing virtual environments for motor rehabilitation: towards a framework for the integration of best-practice information** Thomas Schüler, Luara Ferreira dos Santos, Simon Hoermann
053 ICRAN	**Use of virtual reality game as part of exercise program for chronic patients** Lucía Ortega Pérez de Villar, Borja Pérez Domínguez, Eva Segura Ortí ,Pablo Molina Vila ,MªJesús Lidón Pérez ,Luis Pallardó Mateu ,José Antonio Gil-Gómez
054 ICVR	**The Effects of Haptic Forces on Locomotion and Posture in Post Stroke and Elderly Adults** Gianluca Sorrento, Philippe Archambault
055 ICRAN	**Kinect-based occupational therapy virtual environment for functional neurorehabilitation of the upper limb** Fernando Molina, Cristina Gómez, Julio Ontiveros, Mailin Adriana Villán-Villán, Rodrigo Pérez, Cristina Martín, Eloy Opisso, Josep Medina, José María Tormos, Enrique J. Gómez
056 ICRAN	**Automated Fugl-Meyer assessment for ABI subjects in upper limb physical neurorehabilitation** Mailin Adriana Villán-Villán, Rodrigo Pérez-Rodríguez, Cristina Gómez, Eloy Opisso, José María Tormos, Josep Medina, Enrique J. Gómez
057 INRS	**A Report on Automatized Wheelchair Users' Needs in Korea** Eun Joo Kim, Jung Ah Lee, Jong Woo Park, Hyun Choi, Sung Moon Yoo, Zee-A Han, Hyo Sun Kweon
058 ICRAN	**Effectiveness of Robot-assisted Gait Training According To Clinical Severity of Spinal Cord Injury** Seung-Won Hwang, Hye-Jin Lee, Eun-Joo Kim, Jung-Ah Lee, Deok-Yeon Jo, Sung-Pill Yang, Moon-Hee Lim, Ha-Yeon Kim, Hyun-Kyung Kim
059 ICRAN	**Effect of a Guided Joystick on Input Value Accuracy during Joystick Control** Jung-Ah Lee ,Jae Hyuk Bae, Hyun Choi, Jae Jin Lee, Dong A Kim, Mun Hee Lim, Jin Ju Kim
060 INRS	**Functional independence and gait parameters following haemorrhagic stroke combining conventional rehabilitation and Lokomat® therapy – a case study** Siret Põldur, Mari-Liis Ööpik, Tiiu Tatar, Priit Eelmäe

I Congreso Nacional de Investigación en Enfermería Médico- quirúrgica in Valencia, presented as Oral Comunication

I CONGRESO NACIONAL DE INVESTIGACIÓN EN ENFERMERÍA MÉDICO-QUIRÚRGICA
VALENCIA. 14-15 abril 2016
Sede: Hotel Valencia Palace

VNIVERSITAT DE VALÈNCIA · Facultat d'Infermeria i Podologia
Departament d'Infermeria

RESUMEN COMUNICACIÓN/PÓSTER

TÍTULO

COMPARACIÓN DE UN PROGRAMA DE EJERCICIO INTRADIÁLISIS FRENTE A EJERCICIO DOMICILIARIO SOBRE CAPACIDAD FÍSICA FUNCIONAL , DEPRESIÓN Y CALIDAD DE VIDA RELACIONADA CON LA SALUD

INTRODUCCIÓN

Se ha demostrado que el ejercicio en población con insuficienciena renal crónica en hemodiálisis (HD) aunque son pocas las unidades que ofrecen un programa de ejercicios como tratamiento.

OBJETIVOS

El objetivo de este estudio es comparar los efectos de un programa de ejercicio intradiálisis frente a ejercicio en casa en pacientes en hemodiálisis.

MATERIAL Y MÉTODO

46 pacientes en HD fueron aleatorizados en el estudio en un grupo de ejercicio intradiálisis o en un grupo de ejercicio en casa. Ambos programas consistieron en la combinación de ejercicios de fuerza y ejercicio aeróbico durante 4 meses. Se valoró el Timed Up and Go (TUG), la dinamometría de ambas manos (HG) y se pasó la Escala de Depresión del Centro de Estudios Epidemiológicos (CES-D) y el cuestionario de calidad de vida relacionado con la salud en pacientes con insuficiencia renal crónica (KDQoL-36). El análisis estadístico se realizó mediante una prueba ANOVA mixta.

RESULTADOS

Un total de 23 pacientes, 16 de ellos hombres (grupo intradiálisis n= 11, edad 65.9 (14.9) años; grupo de ejericico en casa n=12, edad 62.4 (12.2) años) finalizaron el estudio y fueron analizados. Hubo un efecto significativo del factor tiempo en el caso del TUG (P=.005), HG derecha (P=.0.044) y HG izquierda (P<.001) y en el CES-D (P=.017). En el KDQoL-36 no hubo cambios signiticativos.

CONCLUSIONES

En ambos grupos se produjo una mejora de la condición tanto física como emocional. Aunque es necesario modificar factores tanto en el personal sanitario que atiende a estos pacientes como en los propios pacientes, para conseguir mayor participación en los programas.

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IX Congreso Internacional de la Asociación Española de Ciencias del Deporte in Toledo (Spain), presented as Oral communication

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JOSÉ MANUEL GARCÍA GARCÍA, DECANO DE LA FACULTAD DE CIENCIAS DEL DEPORTE DE LA UNIVERSIDAD DE CASTILLA-LA MANCHA, EN CALIDAD DE PRESIDENTE DEL COMITÉ ORGANIZADOR DEL IX CONGRESO INTERNACIONAL DE LA ASOCIACIÓN ESPAÑOLA DE CIENCIAS DEL DEPORTE,

HAGO CONSTAR:

Que la **comunicación** denominada ***COMPARACIÓN DE UN PROGRAMA DE EJERCICIO INTRADIÁLISIS FRENTE A EJERCICIO DOMICILIARIO EN PACIENTES EN HEMODIÁLISIS***, realizada por el/los autor/es: **Amer Cuenca J.J., Ortega Pérez De Villar L., Martínez Gramage J., Benavent Caballer V., Biviá Roig G., Segura Ortí E.**, ha sido presentada en el ***IX Congreso Internacional de la Asociación Española de Ciencias del Deporte,*** celebrado en este Campus Tecnológico entre los días 21 y 23 de abril de 2016.

Y, para que conste a los efectos oportunos, firmo la presente en Toledo, a veintitrés de abril de dos mil dieciséis.

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Congreso de Fisioterapia de la Universidad de Castilla la Mancha in Toledo, presented as Oral communication

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Toledo 23 y 24 de octubre de 2015

PRESENTACIÓN DE COMUNICACIÓN

TÍTULO (máximo de 15 palabras, reflejando el contenido de la presentación, sin abreviaturas y escrito en mayúsculas):

COMPARACIÓN DE UN PROGRAMA DE EJERCICIO INTRADIÁLISIS FRENTE A EJERCICIO DOMICILIARIO SOBRE CAPACIDAD FÍSICA FUNCIONAL Y NIVEL DE ACTIVIDAD FÍSICA

AUTOR (nombre y apellidos)	Centro de trabajo con dirección:
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Suelen Cervelli	
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En primer lugar, en la casilla oscura, el autor que presentará la comunicación. Aumentar filas hasta un máximo de 6 autores por comunicación.

RESUMEN (máximo 300 palabras)

Introducción:

Se ha demostrado que el ejercicio para pacientes en hemodiálisis (HD) es beneficio. Sin embargo, son pocas las unidades de HD que ofrecen como rutina de tratamiento un programa de ejercicio adaptado a estos pacientes. El elevado coste de contar con un fisioterapeuta en las unidades es una de las principales causas, por lo que es necesario encontrar alternativas más económicas para generalizar el ejercicio. El objetivo es comparar los efectos de un programa de ejercicio intradiálisis frente a ejercicio en casa.

Material y métodos:

Diecisiete pacientes en HD fueron incluidos y aleatorizados en el estudio en un grupo de ejercicio intradiálisis (GI)(n=9,edad 64.1(14.5) años, 4 hombres) o en un grupo de ejercicio en el casa (HB) (n=8,edad57.8(16.8) años,4 hombres).Siete sujetos del GI y tres del HB abandonaron el estudio. Ambos programas consistieron en la combinación de ejercicios de fuerza y ejercicio aeróbico durante 4 meses. Se valoró la fuerza con la prueba 10 RM (repetición máxima) de extensión de rodilla. Se realizaba cada 4 semanas. El análisis estadístico se realizó mediante una prueba ANOVA split plot.

Resultados:

Un total de 7 pacientes finalizaron el estudio y fueron analizados, 2 pacientes en el GI y 5 pacientes en el HB. La prueba ANOVA split plot mostró un efecto significativo del factor tiempo para el 10 RM ($P<.001$). El 10 RM aumentó tanto en el del GI (mediana del peso pre 2kg, IQ=1.5kg a una mediana del peso post 3.5 kg IQ=1.1kg; como en el HB (mediana del peso pre=3kg, IQ=1 kg; mediana del peso post 3.5kg IQ= 0.8Kg). No hubo diferencias entre ambos grupos.

Conclusiones:

El número de sujetos perdidos es muy elevado en el grupo de ejercicio intradiálisis. El programa del ejercicio a domicilio es una alternativa al ejercicio durante la diálisis ya que se observa un aumento de la fuerza muscular en ambos grupos.

Palabras clave (entre 3 y 5 palabras claves obligatorias)**: Ejercicio, hemodiálisis, insuficiencia renal crónica, fuerza submáxima**

Congreso de Fisioterapia de la Universidad de Castilla la Mancha in Toledo (Spain), presented as Poster

CONGRESO DE FISIOTERAPIA UCLM

Toledo 23 y 24 de octubre de 2015

PRESENTACIÓN DE COMUNICACIÓN

TÍTULO (máximo de 15 palabras, reflejando el contenido de la presentación, sin abreviaturas y escrito en mayúsculas)**:**
REPETIBILIDAD Y MINIMO CAMBIO CLINICO SIGNIFICATIVO PARA EL SHORT PHYSICAL PERFORMANCE BATTERY, EQUILIBRIO MONOPODAL Y TIMED UP AND GO EN PACIENTES EN HEMODIALISIS

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En primer lugar, en la casilla oscura, el autor que presentará la comunicación. Aumentar filas hasta un máximo de 6 autores por comunicación.

RESUMEN (máximo 300 palabras)

Introducción:
Los pacientes con insuficiencia renal crónica en estadio terminal presentan una disminución de la capacidad funcional en las actividades de la vida diaria, aunque la bibliografía muestra falta de consistencia en las pruebas de valoración funcional utilizadas en esta cohorte.
El objetivo de este estudio es determinar la fiabilidad relativa y absoluta de pruebas físicas para evaluar la capacidad funcional, como el *Short Physical Performance Battery* (SPPB), la prueba de equilibrio monopodal y la prueba de *Timed Up and Go* (TUG) en personas en hemodiálisis y determinar el cambio clínico mínimo detectable.

Material y métodos:
Cincuenta pacientes en tratamiento de hemodiálisis pertenecientes a dos hospitales de Valencia. Con una edad media de 62.4 (13.8) años; la media de meses en HD 53 (con un mínimo de 16 y un máximo de 195 meses). Los pacientes completaron el SPPB (n= 49), prueba de equilibrio monopodal (n= 49) y TUG (n= 50). Los participantes fueron evaluados por un mismo observador en dos ocasiones, de forma que los registros se tomaron entre 1 a 2 semanas de diferencia.

Resultados:
El coeficiente de correlación intraclase que se obtuvo en el SPPB fue 0.96 (IC 95% 0.93 hasta 0.98), para el TUG 0.96 (IC 95% 0.93 hasta 0.98) y el equilibrio monopodal 0.84 (IC 95% 0.73 hasta 0.91). El cambio clínico mínimo detectable fue de 1.3 puntos para el SPPB (IC 95% 1.0 hasta 1.8), de 11.9 segundos para el equilibrio monopodal (IC 95% 9.1 hasta 15.4) y de 2.5 segundos para el TUG (IC 95% 1.9 hasta el 3.3).

Conclusiones:
El SPPB y el TUG son pruebas fiables. El cambio clínico mínimo detectable de estas pruebas en pacientes con IRC en estadio terminal pueden ayudar a establecer qué cambios podrían ser importantes en la condición física de estos pacientes en tratamiento de hemodiálisis.

Palabras clave (entre 3 y 5 palabras claves obligatorias)**: Mínimo cambio detectable, fiabilidad, pruebas funcionales, hemodiálisis**

CONGRESO DE FISIOTERAPIA UCLM

Toledo 23 y 24 de octubre de 2015

PRESENTACIÓN DE COMUNICACIÓN

TÍTULO (máximo de 15 palabras, reflejando el contenido de la presentación, sin abreviaturas y escrito en mayúsculas)**:**
CUANTIFICACIÓN DEL DETERIORO FUNCIONAL DURANTE 6 MESES EN PACIENTE RENALES EN ESTADIO TERMINAL

AUTOR (nombre y apellidos)	Centro de trabajo con dirección:
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Javier Martínez Gramage	Universidad CEU Cardenal Herrera
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Andrea Bono Sala	
Eva Segura Ortí	Universidad CEU Cardenal Herrera

En primer lugar, en la casilla oscura, el autor que presentará la comunicación. Aumentar filas hasta un máximo de 6 autores por comunicación.

RESUMEN (máximo 300 palabras)

Introducción:

Los pacientes en tratamiento de diálisis presentan una disminución de la función física, sin embargo, no hay estudios que demuestren el ratio en el que se produce este deterioro funcional. El propósito de este estudio es cuantificar el deterioro funcional de los pacientes en tratamiento de hemodiálisis durante seis meses.

Material y métodos:

Dieciocho pacientes en tratamiento de diálisis de un centro de Valencia (España) fueron analizados después de 6 meses (edad 61.8(14.8) años; media de tiempo en diálisis =5.8 IQR=4 años; mediana IMC = 24.9, IQR = 6.8 kg/m^2). Los participantes completaron el Short Physical Performance Battery –SPPB- (n= 18), equilibrio monopodal (n= 18) and Time Up and Go Test –TUG- (n=17), Sit to stand 10 and 60 –STS 10/STS 60- (n= 16), dinamometría de mano (n=17); elevación de talón (n=17) y 6 minutes walking time -6mwt- (n=17). Además se recogieron datos de las historias clínicas y de las analíticas.

Resultados:

Únicamente se observó cambios significativos en una prueba funcional después de los 6 meses de observación (Dinamometría de mano pre 28.0 (10.2) kg; post 26.3 (10.6) kg p= .09 significativo de manera bilateral). En la elevación del talón se observó un incremento significativo (mediana pre=14.0, IQR= 19.5 repeticiones, mediana post = 19.0, IQR= 19.0 repeticiones p= .074, significativo de manera bilateral). En la prueba TUG ambas mediciones pre y post se observó por debajo de 10 segundos, lo que es considerado un tiempo normal de ejecución.

Conclusiones:

Se trata de una muestra de pacientes en hemodiálisis limitada y relativamente joven con un buen estado físico de salud. Después de 6 meses, en ninguna de las pruebas de capacidad funcional se observa un deterioro significativo. Se recomienda a los centros de hemodiálisis realizar un seguimiento de capacidad funcional anualmente, ya que con un periodo de 6 meses no se encuentran cambios significativos.

Palabras clave (entre 3 y 5 palabras claves obligatorias)**: Deterioro, hemodiálisis, insuficiencia renal crónica**

CONGRESO DE FISIOTERAPIA UCLM

Toledo 23 y 24 de octubre de 2015

PRESENTACIÓN DE COMUNICACIÓN

TÍTULO (máximo de 15 palabras, reflejando el contenido de la presentación, sin abreviaturas y escrito en mayúsculas)**:**

EFECTOS DEL EJERCICIO DOMICILIARIO EN PACIENTES CON DIFERENTES GRADOS DE INSUFICIENCIA RENAL CRÓNICA

AUTOR (nombre y apellidos)	Centro de trabajo con dirección:
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Vicent Benavent Caballer	Universidad CEU Cardenal Herrera
Francisco Palomo Peña	
Inmaculada Simó Martínez	
Eva Segura Ortí	Universidad CEU Cardenal Herrera

En primer lugar, en la casilla oscura, el autor que presentará la comunicación. Aumentar filas hasta un máximo de 6 autores por comunicación.

RESUMEN (máximo 300 palabras)

Introducción:

Se ha demostrado que el ejercicio para el paciente con insuficiencia renal crónica es beneficioso. Sin embargo, el elevado coste de contar con un fisioterapeuta hace difícil la generalización de los programas de ejercicio, por lo que es necesario encontrar alternativas más económicas. El objetivo es comparar los efectos de un programa de ejercicio en casa en un grupo de pacientes con diferentes grados de enfermedad renal crónica (pre-diálisis, dializados o trasplantados).

Material y métodos:

Doce sujetos pertenecientes a la Asociación de Lucha contra las Enfermedades del Riñón (ALCER) en Valencia. Se utilizó una batería de pruebas funcionales antes y después de la intervención, que incluyeron la dinamometría de mano, equilibrio monopodal, 6 minutos marcha -6mwt-, *Short Physical Performance Battery –SPPB-*, *Sit to Stand to Sit* en 60 segundos –STS 60- y *Timed Up and Go –TUG-*. Se les entregó un programa de ejercicio a realizar en su domicilio, que incluía ejercicios con banda para miembros inferiores y miembros superiores. Se pidió a cada sujeto que rellenara un diario de actividad. El análisis estadístico se realizó mediante un test de Wilcoxon.

Resultados:

Siete sujetos finalizaron el estudio (2 mujeres y 5 hombres; edad media 64.2 ± 10.1 años; IMC= 29.2 ± 6.6 kg/m^2). 2 sujetos eran transplantados, 2 estaban en tratamiento de hemodiálisis, uno se encontraba en fase III de la enfermedad renal, otro en fase IV y uno en prediálisis. y fueron analizados. Se observa que tras los 3 meses de ejercicio en el domicilio hubo una mejora significativa en dinamometría de mano derecha (inicial 28.9 ± 7.5 kg, final 32.0 ± 7.1 kg; P= 0.009) y de la izquierda (inicial 27.1 ± 8.4 kg, final 29.9 ± 8.5 kg; P= 0.009); un incremento significativo del número de repeticiones en el STS-60 (inicial 23.7 ± 5.0 reps, final 30.0 ± 5.8 reps; P= 0.009); y una disminución en el tiempo de realización de la prueba TUG (inicial 7.2 ± 0.1 seg, final 5.7 ± 1.4 seg; P= 0.032).

Conclusiones:

Un programa de ejercicio domiciliario de 3 meses de duración produce mejoras significativas en un grupo heterogéneo de sujetos con enfermedad renal en distintos estadios de enfermedad renal en algunas variables funcionales.

Palabras clave (entre 3 y 5 palabras claves obligatorias)**: Ejercicio, hemodiálisis, insuficiencia renal crónica**

40 Congreso Nacional de La Sociedad Española de Enfermería Nefrológica (SEDEN), in Valencia (Spain), presented as Oral Comunication

11.00 - 12.30 h. **4ª SESIÓN DE COMUNICACIONES ORALES**

MODERADORAS:

- **Dña. Anna Junqué Jiménez**
  Brand Ambassador EDTNA/ERCA Spain
  Hospital de Terrassa. Barcelona
- **Dña. Ana Purificación Collado Mora**
  Enfermera del Servicio de Nefrología
  Hospital Universitario Dr. Peset. Valencia

PONENTE:

11.00 h. **"Implantación de un programa de ejercicio durante la hemodiálisis vs ejercicio en el domicilio"**

- **Dña. Lucía Ortega Pérez de Villar**
  Doctoranda de fisioterapia en pacientes renales
  Profesora asociada de la Universidad CEU Cardenal Herrera. Valencia

COMUNICACIONES ORALES:

11.20 h. **COMPARACIÓN DE UN PROGRAMA DE EJERCICIO INTRADIÁLISIS FRENTE A EJERCICIO DOMICILIARIO SOBRE CAPACIDAD FÍSICA FUNCIONAL Y NIVEL DE ACTIVIDAD FÍSICA**
Lucía Ortega Pérez de Villar, Sara Antolí García, Mª Jesús Lidón Pérez, Juan José Amer Cuenca, Vicent Benavent Caballer, Eva Segura Ortí
Hospital Universitario Dr. Peset. Valencia

11.30 h. **ELECTROESTIMULACIÓN NEUROMUSCULAR INTRADIÁLISIS, FUERZA MUSCULAR, CAPACIDAD FUNCIONAL Y COMPOSICIÓN CORPORAL**
Sandra Rubio Páez, Ester Tomás Bernabeu, Anna Junqué Jiménez, Óscar Paz López, Gorka Iza Pinedo, Marisa Lavado Sempere
Hospital Terrassa. Barcelona

11.40 h. **¿CUÁL ES LA RELACIÓN ENTRE FUNCIÓN SEXUAL Y SINTOMATOLOGÍA ANSIOSO-DEPRESIVA EN PACIENTES EN DIÁLISIS DOMICILIARIA?**
Helena García Llana, Olga Celadilla Díaz, Ana Margarida Graça, Isabel Muñoz Gutiérrez, Gloria del Peso Gilsanz, Filo Trocoli García
Hospital Universitario La Paz. IdiPAZ. y Centro Hospitalario do Algarve. Madrid y Faro (Portugal)

11.50 h. **CUANTIFICACIÓN DEL DETERIORO FUNCIONAL DURANTE 6 MESES EN PACIENTES RENALES EN ESTADÍO TERMINAL**
Lucía Ortega Pérez de Villar, Sara Antolí García, Mª Jesús Lidón Pérez, Juan José Amer Cuenca, Javier Martínez Gramage, Eva Segura Ortí
Hospital Universitario Dr. Peset. Valencia

12.00 h. **ESTUDIO COMPARATIVO DEL ESTADO FÍSICO, MENTAL Y PERCEPCIÓN DE CALIDAD DE VIDA RELACIONADA CON LA SALUD DE LOS PACIENTES EN DIÁLISIS**
Elisabeth Tejeda Aráez, Eva Barbero Narbona, Cristina Herrera Morales, Silvia Montserrat García, Nuria Gasco Coscojuela, Ernestina Junyent Iglesias
Hospital del Mar. Barcelona

12.10 h. **COLOQUIO**

24 MIÉRCOLES 7 - AUDITORIO 3B

XLV Congreso Nacional de La Sociedad Española Nefrología (SEN), in Valencia (Spain), presented as Poster

Detalle

Núm Referencia:
562

Título:
COMPARACIÓN DE UN PROGRAMA DE EJERCICIO INTRADIÁLISIS FRENTE A EJERCICIO DOMICILIARIO SOBRE CAPACIDAD FÍSICA FUNCIONAL Y NIVEL DE ACTIVIDAD FÍSICA

Autor que presentará el trabajo:
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Cuerpo del resumen:

INTRODUCCIÓN: Desde hacer años se vienen implantando ejercicios para pacientes en hemodiálisis (HD),demostrando su beneficio. Sin embargo,son pocas las unidades de HD que ofrecen como rutina de tratamiento un programa de ejercicio adaptado a estos pacientes.El elevado coste de contar con un fisioterapeuta en las unidades es una de las principales causas, por lo que es necesario encontrar alternativas más económicas para generalizar la realización de ejercicio.El objetivo es comparar los efectos de un programa de ejercicio intradiálisis frente a ejercicio en casa, la adherencia al programa, la capacidad física funcional y el nivel de actividad física.

MÉTODOS: Diecisiete pacientes en HD fueron incluidos y aleatorizados en el estudio en un grupo de ejercicio intradiálisis (GI)(n=9,edad 64.1(14.5) años, 4 hombres) o en un grupo de ejercicio en el casa (HB) (n=8,edad57.8(16.8) años,4 hombres).Siete sujetos del GI y tres del HB abandonaron el estudio. Ambos programas consistieron en la combinación de ejercicios de fuerza y ejercicio aeróbico durante 4 meses con un total de 48 sesiones. Se valoró una amplia batería de pruebas funcionales (*Short Physical Performance Battery*, equilibrio monopodal, *Timed up and go, Sit to stand to sit test* 10 y 60,dinamometría de mano, fuerza de tríceps, 6 minutos marcha) y dos cuestionarios de nivel de actividad física. El análisis estadístico se realizó mediante una prueba ANOVA mixta.

RESULTADOS: Un total de 7 pacientes finalizaron el estudio y fueron analizados, dos pacientes en el GI y 5 pacientes en el HB. La prueba ANOVA mixta mostró un efecto significativo del factor tiempo sólo en el caso del cuestionario de actividad física *Human Activity Profile* (P<.017) donde la mediana de los pacientes del GI tenían una puntuación pre de 48.5 (min44 - max 53) y post de 62 (min 8 - max 66); mientras en el HB obtuvieron una puntuación pre de 7 (min 2 - max 54) y post de 17.5 (min 13 y - max 86). Respecto al resto de pruebas funcionales, no se encontró ninguna diferencia significativa.En cuanto a la adherencia a los programas de ejercicios los pacientes del GI cumplieron el 92.70 % del total de las sesiones,mientras que HB el 68.74%.

CONCLUSIONS: Tanto GI como el ejercicio HB resultan en un aumento del nivel de actividad física de los pacientes en hemodiálisis.Es necesario modificar factores, tanto en el personal sanitario que atiende a estos pacientes como en los propios pacientes, para conseguir mayor adherencia a los programas de ejercicio

Tipo de comunicación:
Oral (acepto Poster)

Temas:
Hemodiálisis - Otros temas HD 2

Medios audiovisuales:
Cañon + Ordenador

Archivo adjunto:
No

Presentación:
Estado final del trabajo: Aprobado
Tipo de comunicación final: Póster
Sala: HEMODIÁLISIS - OTROS TEMAS
Fecha: No asignada.
Número de Póster: 188

XXV Jornadas de Fisioterapia Organizada por la Escuela Universitaria de Fisioterapia de la ONCE, in Madrid (Spain), presented as Poster

Fiabilidad del test-retest, mínimo cambio clínico significativo para el SPPB, equilibrio monopodal y TUG en pacientes en Hemodiálisis

Test-Retest reliability and minimal detectable changes score for SPPB, one leg stance and TUG in people undergoing Haemodialysis

Ortega, L. Martínez-Olmos, F. Amer-Cuenca, J. Martínez-Gramaje, J. Benavent, V. Segura-Ortí, E.

Universidad CEU Cardenal Herrera.

Introducción: Los pacientes con insuficiencia renal crónica en estadio terminal presentan una disminución de la capacidad funcional. La bibliografía muestra diferentes pruebas de valoración funcional, pero en algunas de ellas no se han dado valores fiabilidad absoluta y relativa.

Objetivo: El objetivo de este estudio es determinar la fiabilidad relativa y absoluta de pruebas físicas como el Short Physical Performance Battery (SPPB), la prueba de equilibrio monopodal y la prueba de Time Up and Go (TUG) en personas en hemodiálisis y determinar el cambio mínimo detectable en este tipo de población.

Material y métodos: Se trata de un estudio observacional y prospectivo. Participaron veintinueve pacientes en hemodiálisis pertenecientes a un hospital de Valencia, que completaron el SPPB (n= 24), prueba de equilibrio monopodal (n= 24) y TUG (n= 25). Los participantes fueron evaluados por un mismo observador en dos ocasiones, de forma que los registros se tomaron entre 1 a 2 semanas de diferencia.

Resultados: El coeficiente de correlación intraclase obtenido para la prueba SPPB fue 0.94 (IC 95% 0.86 a 0.97), para el TUG 0.97 (IC 95% 0.94 a 0.99) y para la prueba de equilibrio monopodal 0.71 (IC 95% 0.44 a 0.86). El valor del mínimo cambio detectable fue de 1.6 puntos para el SPPB (IC 95% 1.1 a 2.4), 15.6 segundos para el equilibrio monopodal (IC 95% 10.7 a 21.7) y 2.4 segundos para la prueba TUG (IC 95% 1.5 a 3.5).

Conclusiones: Las pruebas SPPB y TUG presentan una elev da fiabilidad relativa. Los cambios clínicamente importantes en estas pruebas para pacientes con insuficiencia renal crónica en

estadio terminal permiten establecer qué nivel de cambio será importante para el estado funcional de estos pacientes.

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Palabras clave: Hemodiálisis, capacidad funcional, fiabilidad, calidad de vida
Key words: Haemodialysis, functional capacity, reliability, quality of life

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