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The Physiological and Psychological Responses to Submaximal Exercise at Different Times in Renal Disease Patients.

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THE PHYSIOLOGICAL AND PSYCHOLOGICAL RESPONSES TO SUBMAXIMAL EXERCISE AT DIFFERENT TIMES IN RENAL DISEASE PATIENTS

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ABSTRACT

This study investigated cardiorespiratory, hematological, and psychological responses to acute submaximal exercise and recovery in end stage renal disease patients. Five African-American males on hemodialysis, were randomly assigned to three exercise treatments (30 minutes on the treadmill at 60% VO_2peak): pre dialysis (2 hours before), post dialysis (1 hour after), and off dialysis (24 hours after last dialysis). The cardiorespiratory (CR) variables were: ventilation (V_E), oxygen consumption (VO_2), carbon dioxide production (VCO_2), respiratory exchange ratio (R), and kilocalories (KCAL/min). The hematological variables were: blood urea nitrogen (BUN), creatinine (Cr), albumin (Al), total protein (Tp), glucose (Gl), sodium (Na^{++}), potassium (K^+), hemoglobin (Hg), hematocrit (Ht), ammonium (NH_4), creatine phosphokinase (CPK), lactate dehydrogenase (LDH), partial pressure of oxygen (PaO_2), partial pressure of carbon dioxide ($PaCO_2$), pH, bicarbonate (HCO_3), and saturation of oxygen (SaO_2). The psychological variables were: Borg's rating of perceived exertion (RPE), Multiple Affect Adjective Checklist (MAACL), and Nonspecific Symptoms Questionnaire (NSQ). A randomized block design was used to analyze the data ($p<.10$), with Newman-Keuls post hoc test ($p<.05$). There were significant treatment effects for the following CR variables: VO_2, VO_2/kg, and kcal/min. VO_2/kg was significant when treatments were compared (highest post dialysis, then off dialysis, lowest pre dialysis). There was a significant difference for the time effect for glucose (baseline concentration was higher than the concentrations during and after the exercise). There were significant differences for the treatment effects in: BUN, Cr, Na^{++}, K^+, pH, LDH, CPK and

HCO_3 (differences were pre vs. post, and post vs. off). Only LDH and CPK were significantly different in pre vs. off. There were time effects in shortness of breath, joint pain, cramps, and muscle weakness. Exercise relieved the symptoms. Mood scores for depression had a significant treatment effect (post vs. off). This study demonstrated that these patients can safely exercise at 60% of VO_2peak. In conclusion, kidney disease patients need to be encouraged to participate in exercise for the acute psychological effects and the long term physiological effects.

INTRODUCTION

In 1992, a quarter of a million individuals had end stage renal disease in the United States, resulting from three primary diseases: diabetes (69,247), hypertension (60,528), and glomerulonephritis (40,791). The incidence for that year included 54,586 new cases. The amount of money, public and private, spent annually to treat this disease was $9.5 billion dollars. (National Institute of Diabetes and Digestive and Kidney Diseases from the National Institutes of Health, 1992) These figures exemplify the social and economical impact that kidney disease has in the American society. For the past 2 decades, a holistic approach has been used to treat kidney disease, including psychological care and increasingly utilizing exercise. The inclusion of exercise is based on positive effects that it has for prevention and rehabilitation of secondary diseases in kidney disease, such as hypertension, diabetes, and arteriosclerosis.

With the implementation of exercise, patients have been able to increase their working capacity (Harter & Goldberg, 1985; Painter, et al., 1986a; Goldberg, et al., 1986); reduce their blood pressure and use of blood pressure medication (Painter, et al. 1986 a & b; Painter & Zimmerman, 1986; Goldberg, et al., 1983; Harter & Goldberg, 1985; Hagberg, et al., 1983); improve their lipid profile (Goldberg, et al., 1983), and improvement in some psychological characteristics such as depression, anxiety, and self- esteem (Carney, et al., 1987; Goldberg, et al., 1980; Maher, et al., 1983).

Some researchers indicate that exercise might not be beneficial for all the people who have kidney disease. Lundin, et al. (1987), found that functionally anephric uremic patients might be expected to have altered acid-base and biochemical responses to the stresses of exercise, some of which might prove harmful. Cianflocco (1992) documented the effects of exercise-related conditions in healthy kidneys such as: proteinuria, hematuria, and renal trauma. Cianflocco advises extreme caution when prescribing exercise to kidney disease patients because there is evidence that proteinuria, hematuria, renal trauma, and acute renal failure can develop with intense exercise in healthy kidneys. Therefore, if the kidneys are prone to develop any disease or are already diseased, the stress of exercise may exacerbate the preexisting condition. Taverner, et al. (1991), concluded that the diseased kidney is unable to maintain glomerular filtration rate or conserve water under the stress of exertion as well as the normal kidney. They found that subjects with impaired renal function showed a significant fall in glomerular filtration rate on exertion, urine osmolality did not rise with exertion, and free water clearance became negative after exercise in the normal group only. These studies raise the question whether individuals with a history of renal disease can participate in *intense* physical activity. For example, there have been reports by patients of episodes of hypotension one hour after completion of dialysis (Painter, et al., 1986a). Daul, et al., (1995) found that exercise increases arterial K^+ level in dialysis patients. This could be potentially life threatening, because of the effects that K^+ has on cardiac arrhythmias.

Other investigators have found that prolonged exercise at *moderate* intensities can be performed safely by these patients (Moore, et al.,1993; Kettner, et al., 1984; Burke, et al., 1983). Burke, et al. (1983), compared the cardiorespiratory and hematological responses to exercise at a given submaximal workload on and off hemodialysis treatment. They concluded that there were no substantial differences between these physiological responses to exercise on and off hemodialysis. They further suggested the potential use of exercise during hemodialysis to improve their cardiovascular fitness. Kettner, et al. (1984), also suggested that chronic hemodialysis patients can exercise at modest intensity without untoward cardiovascular or metabolic responses.

One of the problems in this population is the attrition rate in these exercise programs. The number of patients that stay in an exercise program is very low, less than 50% (Dishman, 1987). In a study conducted by Shalom, et al. (1984), 174 patients receiving maintenance hemodialysis were asked to participate in a 12 week exercise conditioning program. From those 174, fifty qualified for the study and were cleared by their physicians. Only fourteen participated in the exercise program, with seven of those patients attending more than 50% of the exercise sessions. They concluded that despite the potential benefit of exercise conditioning programs for dialysis patients, it's impact may be limited because only a small portion of patients are able or willing to participate. Williams, et al. (1991), mentioned several reasons why these patients do not participate in exercise programs. They indicated that physical symptoms and psychological state are the primary factors influencing the determination to participate in an exercise program. There is a lack of information on the acute effect of exercise on mood, and physical symptoms. Mood and physical symptoms are contributors of depression, anxiety and self-esteem (Carney, et al., 1983; Brown, 1984; Carney, et al., 1986). Research performed on physically healthy individuals with psychological problems found that acute exercise improved the scores of mood, anxiety and stress (Biddle, 1992). If exercise acutely changes their mood and physical symptoms, then the patients will be more likely to engage in an exercise session again (Biddle, 1992). Also, accomplishing goals like exercising every day, empowers patients and improves feelings of well being, self efficacy, and enjoyment. All these feelings lead to adherence to their medical treatment and health promoting behaviors (Wankel, et al., 1993; Duncan and McAuley, 1993). In another study, Martisen and Medhus (1989) asked patients who had been treated for depression in a hospital setting to rank the different elements (i.e., medication, community meetings, contact with other patients, group psychotherapy, physical exercise, individual psychotherapy, and contact with milieu staff) in their treatment program. The patients ranked physical exercise as the most important element in their comprehensive treatment. This demonstrates how exercise can contribute positively in the treatment of some psychological problems.

The literature on exercise, hemodialysis, and psychological status has concentrated on investigations that explore the effects of exercise training on psychological variables (Carney, et al., 1983; Carney, et al., 1986; Maher, et al., 1983; Goldberg, et al., 1980). Among the variables investigated are depression, anxiety, stress, and self-esteem. Some investigations have found that exercise training reduced anxiety (Brown, 1984), depression (Goldberg, et al., 1980; Carney, et al., 1983), and self-esteem (Maher, et al.,1983).

Renal disease patients develop a syndrome called uremia. This. is a multidimensional malaise in which accumulation of waste products (primarily nitrogenous) in the blood occurs due to the kidney's inability to filtrate them. A range of symptoms develop such as anemia, high blood pressure, sexual problems, foul taste, ammonia breath, appetite decline, vomiting, itching, cramps, sleep disturbances, bleeding, volume overload, and chest pain (Knochel & Seldin, 1981). The dialysis will ameliorate these symptoms by removing the excess volume and the metabolites; but after dialysis their accumulation will start again.

The timing of the exercise bout for kidney patients has not been systematically investigated. Some investigations have studied the effects of exercise during dialysis ("on") and on the day that they do not have to dialyze ("off"). Moore, et al. (1993), studied the determinants of VO_2peak in patients with end stage renal disease on and off dialysis. They found no significant differences between exercise performed on dialysis and off dialysis. They concluded that performing exercise testing off dialysis in order to prescribe exercise training on dialysis is a valid technique. The existent studies have compared exercise while on dialysis versus exercise off dialysis. The exercise off dialysis has not been controlled. For example, in one study the off dialysis exercise was performed 2 hours prior to dialysis (Moore, et al., 1993), in another study it was at least 24 hours after last dialysis (Kettner, et al., 1984), and in another study the time at which the patients were exercised off dialysis was not mentioned (Burke, et al., 1983). Therefore, more investigations are needed that will explore the responses to exercise at different times in the dialysis population.

Purpose

This study determined the cardiorespiratory, hematological, and psychological responses to acute submaximal exercise and recovery prior to, following, and on the day off dialysis in hemodialysis patients.

Hypotheses

It was hypothesized that:

1. Dialysis patients with the characteristics of the subject group can exercise safely as indicated by acceptable levels in the blood of K^+, Na^{++}, blood urea nitrogen, creatinine, and glucose.

2. Submaximal exercise in dialysis patients will result in increasing levels of stress from pre to off to post dialysis, as indicated by increased metabolites.

3. Different degrees of uremic state will have an effect on mood and physical symptoms, with higher scoring on the scales for anxiety, hostility, depression, and physical symptoms from pre to off to post dialysis.

REVIEW OF LITERATURE

This chapter is focused on reviewing the existent literature on the effects of exercise in kidney disease patients. The review includes the effects of training in kidney disease patients, the differences between "normal" responses to exercise compared to the responses of kidney disease patients, the physiological responses of exercise performed while on dialysis versus off dialysis, and the psychological status of kidney patients.

The kidneys are a pair of organs that lie behind the peritoneum in the posterior aspect of the abdomen on each side of the vertebral column. The kidneys' basic functions are: eliminate urea and other toxic substances, regulate the concentration of salt in the body, and regulate urine output (Brenner & Rector, 1977; Maude, 1977).

The kidneys receive about 25% of the resting cardiac output, more than 1L of blood per minute (Brenner & Rector, 1977). The major metabolic function of the kidneys is to provide itself with the energy required to reabsorb the vast quantities of salt and water filtered. The kidneys produce hormone-like substances such as prostaglandins, which function as autoregulators to maintain renal blood flow and fluid excretion, and act as hypertensive agents, as well as erythropoietin that is a glycoprotein that stimulates red blood cell production. The kidneys also interact with other humoral systems. For example, long term regulation of blood pressure is a function of the kidneys through the renin-angiotensin system (Brooks & Fahey, 1984).

Uremia

Renal failure is defined as the loss of renal excretory functions. It may be the result of impaired renal vascular perfusion. obstruction to the outflow of urine. or intrinsic kidney disease. Therefore. it is always associated with a decreased glomerular filtration rate. Regardless of the cause. renal failure is associated with elevation of blood-urea-nitrogen (BUN), creatinine, and other nitrogenous waste. Azotemia is the retention of such products in the blood. Usually the body is able to tolerate the azotemia well until it reaches a critical point where the person starts to feel ill (Brenner & Rector, 1977; Maude.1977).

The signs and symptoms of uremia (urine in the blood) are the following: glomerular filtration rate falls below 15-20 ml/min. creatinine levels above 10. BUN is 100 or weakness. fatigue. nausea, vomiting, anemia. bleeding, weight loss. and muscle wasting. Uremia will have an effect in other physiological systems as well. Hyperkalemia and metabolic acidosis are very common. This is due to the fact that these people are unable to maintain fluid balance. even when ingesting normal quantities of salt and water (Brenner & Rector.1977; Maude. 1977).

Hvpertension

Hypertension can be both a cause and a consequence of renal disease. Blood pressure is the product of cardiac output and peripheral resistance. Acute regulation is determined by the sympathetic nervous system. whereas long term regulation is a function of the kidneys.

Primary, or essential, hypertension is when the elevation of blood pressure can be attributed to a known cause. It can be associated with a coexisting disease that may produce such effects. Secondary hypertension is when different diseases produce physiological alterations that produce an increase in blood pressure. The following are conditions that are associated with secondary hypertension: renal artery stenosis, primary intrinsic renal disease, primary hyperaldosterism, adrenal cortex hyperfunction, brain injury, coarctation of the aorta, and pheochromocytoma (Maude, 1977).

Among the complication of hypertension that involve the vascular and renal systems is arteriosclerosis. The process of arteriosclerosis is part of aging, but there are certain factors that can precipitate the disease. The development of atheromatous plaque causes degenerative changes in the vessel that will raise the blood pressure. Another complication involving the kidney directly is a decline in renal function. When the ability of the kidneys to excrete salt and water is compromised, then the result will be an increase in extracellular and plasma volume, thus, increasing blood pressure. A decreased renal perfusion will stimulate renin release leading ultimately to an increase in blood pressure. This can lead to deficiency in renal prostaglandins production increasing blood pressure due to inappropriate activation of the renin-angiotensin system. Intrinsic renal disease leads to hypertension, due to fluid overload or lack of vasodilation when blood pressure is high. Nevertheless, at present the role of kidney disease in the genesis of hypertension is not clear.

Exercise. Kidney Disease and the Cardiorespiratory System

In this section, the relationship of exercise and kidney disease will be explored. The idea of exercise as an intervention in this population was derived from the fact that exercise has been used positively as part of the treatment/rehabilitation in other diseases such as coronary artery disease.

In general, the response to exercise is an increased cardiac output (increased heart rate and blood pressure) with increased oxygen consumption, increased pulmonary ventilation, and increased energy production derived from aerobic and anaerobic pathways (Painter & Zimmerman, 1986). In terms of the kidneys during exercise, blood flow to the kidneys is reduced, glomerular filtration rate is reduced, filtration fraction is increased, and urinary flow and urinary water excretion are reduced (Taverner, et al., 1991; Cianflocco, 1992; Ala-Houla, 1990). Activation of the sympathetic system with increasing levels of catecholamines results in the vasoconstriction of the renal efferent arterioles affecting renal filtration. The role of the anti-diuretic hormone (ADH) appears to be the most significant factor in the regulation of water excretion.

It is well documented that kidney disease patients have low exercise tolerance and capacity. It has been found that physical working capacity of patients on hemodialysis to be around 51% of that of normal sedentary individuals (Barnea, et al., 1980; Painter, et al., 1986a & b; Painter & Zimmerman, 1986; Sagiv, et al., 1991). Aerobic exercise training does improve functional capacity as measured by $VO2_{max}$ (peak) testing in kidney disease patients (Harter & Goldberg, 1985; Painter, et al., 1986 a & b; Goldberg, et al., 1983; Shalom, et al., 1984; Roseler, et al., 1980). This improvement has been reported to be between 15-42% of their original VO_{2peak}, but it is still lower than expected for age-sex matched group. A possible explanation for this low VO_{2peak} is the limited O_2 delivery due to low peak heart rate and low arterial oxygen content (Moore, et al., 1993). The majority of kidney disease patients suffer from anemia, thus affecting the oxygen carrying capacity. Also, these patients never reach their maximum because they terminate the test early, when they express volitional fatigue or leg fatigue; and they are never encouraged to "max out".

Moore, et al. (1993), examined the determinants of VO_{2peak} in patients with end stage renal disease (ESRD). They found that VO_{2peak} was below the 95% confidence limit for normals. They also found that stroke volume (SV) was similar to that of normals, peak heart rate (HR) was 77% of predicted, and hematocrit (HT) was 27% of predicted. In another study, Lewis, et al. (1992) examined the ventilatory cost of exercise compared in chronic heart failure and chronic renal anemia. They found that exercise capacity was reduced in both groups. They argued that an increased respiratory exchange ratio (RER) at peak exercise implied anaerobic metabolism due to limited oxygen in heart failure and limited oxygen carrying capacity in anemia.

The mortality related to cardiovascular complications is quite high in renal disease patients (Goldberg, et al., 1979; Ayus, et al., 1981; Shalom, et al., 1984; Lundin, et al., 1987). The range of cardiovascular complications covers a handful of abnormalities. First, the most prevalent is the premature or accelerated development of arteriosclerosis. This event is accelerated due to abnormal lipid profile and lipid metabolism. The kidney disease patient suffers from hypertriglyceridemia. reduced levels of high density lipoprotein (HDL), and increased levels of very low density lipoprotein (VLDL) (Harter & Goldberg, 1985; Ayus, et al., 1981; Goldberg, et al., 1979).

In general, it has been demonstrated that aerobic exercise training improves the lipid profile in kidney disease patients (Goldberg, et al., 1979; Harter & Goldberg, 1985). Golberg, et al. (1979) found that after an average of 12 months of aerobic training, the levels of plasma triglycerides and VLDL decreased. along with an increase in HDL concentrations. Other researchers have not found changes in lipid profile perhaps due to a shorter length of training period and lower percent attendance to the training program.

Hypertension is another complication of kidney disease. Hypertension appears in this population as result of volume overload, abnormalities in the renin-angiotensin system, or autonomic dysfunction (Hagberg, et al., 1983). In hypertensive patients, hemodialysis provides adequate treatment to reduce their blood pressure. If high blood pressure persists after dialysis, however, then medications and, potentially, exercise are the treatments of choice. The proposed mechanism by which exercise lowers blood pressure in kidney patients are: decreased plasma volume, direct effect of exercise on the sympathetic nervous system, renin-angiotensin system or peripheral vascular resistance. It has been demonstrated that after aerobic exercise training, hypertensive dialysis patients are able to stabilize their blood pressure. The effects of exercise may result in a reduction or even complete withdrawal of medication (Painter, et al., 1986b; Goldberg, et al., 1983; Hagberg, et al., 1983; Harter & Goldberg, 1985; Goldberg, et al., 1979; Ayus, et al., 1981).

There is a lack of information about the responses to exercise at different times in this population. The studies that have been conducted compared the performance of the exercise while they are on dialysis with exercise performed at another time. The rationale for these studies was to document that these patients can perform exercise safely while they are on dialysis. Reasons for including exercise during dialysis include: 1) it gives the patients something to do while they are getting treatment; 2) there is supervision from the dialysis center staff while they are exercising. Nevertheless, there are some restrictions for exercising while on dialysis because of the possibility of hypotension episodes during the second hour of dialysis (Painter, et al., 1986a). In addition, most of the patients do not want to be bothered or be active while they are on dialysis, which is a grueling process that drains them of their energy.

These studies have determined the responses to different types of exercise: 1) exercise to fatigue; 2) submaximal exercise at 50% for 1 hour; 3) intermittent exercise when performed while the patients are on dialysis versus another time off dialysis. Each study measured different variables, and as a consequence it is difficult to draw general conclusions from these studies. Moore, et al. (1993) studied the determinants of VO_2peak in dialysis patients. They compared the responses to peak exercise while they were dialyzing versus exercise off dialysis (prior to dialysis). They measured ventilation, oxygen uptake, cardiac output, heart rate, hemoglobin, hematocrit, arterial blood gases, and pH. They found no differences in oxygen uptake, cardiac output, heart rate, stroke volume, or arteriovenous oxygen differences. Therefore, they concluded that up to 1 hour of dialysis minimally affects VO_2peak. Burke, et al.(1983 & 1984), studied the responses to intermittent submaximal exercise while dialyzing versus off dialysis in a group of dialysis patients. They measured electrolytes, blood gases, and cardiorespiratory data. They found no evidence that exercise was contraindicated when it was performed while on dialysis. Kettner, et al., (1984), studied the cardiovascular and metabolic responses to submaximal exercise in dialysis patients. They compared one hour of exercise performed on the cycle ergometer at 50% of their VO_2max between a control group and a group of dialysis patients. The exercise was performed 24 hours after the last dialysis. The variables measured were: norepinephrine, epinephrine, insulin, glucagon, glucose, lactate, protein, hemoglobin, hematocrit, heart rate, blood pressure, respiratory exchange ratio, and VO_2. They demonstrated that dialysis patients are capable of working at submaximal workloads for one hour without significant abnormalities in cardiovascular hemodynamics or glucose homeostasis.

Other investigations that examined the responses to exercise were training studies (Painter, et al., 1988; Goldberg, et al., 1980). The study by Painter, et al., (1986b) was designed to be performed while the patient was on dialysis. Whereas the study by Goldberg, et al. (1980) was designed to be performed when the patient was off dialysis. Both studies found improvement in some variables such as: VO_2max, working capacity, and glucose tolerance. In some other variables there were no change (e.g., creatine, blood urea nitrogen). In terms of lipid profile and metabolism, Goldberg et al. 1980, found significant changes, including decreased LDL, and increased HDL, and reduced total cholesterol.

Kidney Disease and Psychological Status

Kidney disease is a source of detrimental stress to the patient. Consequently, these patients develop an array of psychological disorders sometimes to a point that they have to be treated clinically. Maher, et al. (1983), described four sources of stress for the patient in hemodialysis: 1) the consciousness of the life threat in kidney failure; 2) the exigencies of the dialysis regimen (e.g., adherence to diet, medication, fluid restriction, attendance to treatment); 3) secondary consequences of kidney failure and dialysis (e.g., loss of employment, marital/sexual problems, financial problems); and 4) the impaired bodily function associated with dialysis. Maher, et al. (1983) suggested that it is important to have a good family/social network, maintain a good positive self-esteem and financial independence in order to counterbalance the effects of stress.

Depression is reported to be the most frequent psychological consequence in patients with ESRD (Carney, et al., 1986; Carney, et al., 1987; Goldberg, et al., 1986; Goldberg, et al., 1980). Anxiety, hostility, social interaction, self-esteem, and out look for the future are also affected by kidney disease (Maher, et al., 1983; Brown, et al., 1984; Goldberg, et al., 1986; Goldberg, et al., 1980; Carney, et al., 1986, Carney, et al., 1987).

A relationship between physical fitness and health has been established with respect to other systemic diseases (Brown, et al., 1984). Goldberg, et al. (1980) found that exercise was associated with a reduction of hypertensive medications, and a rise in hemoglobin and hematocrit. At the same time exercise was associated with an improvement in depression, hostility, anxiety and social interaction. Hence, exercise helps to ameliorate or improve physical ailments of kidney disease and at the same time the patients begin to feel good about themselves because they feel they are more in control and somewhat independent with better self-esteem. Carney, et al. (1987) reported that exercise not only can improve levels of depression, but it can also increase the performance of pleasant activities among dialysis patients. Therefore, exercise is a viable tool for treatment of the psychological disorders that affect kidney disease.

Although exercise appears to provide desirable physiological and psychological changes, the adherence to an exercise program is somewhat low in this population. Williams, et al. (1991) found that the non-adherent patients can be distinguished because they posses a distinctive set of physiological, social and psychological characteristics, including: 1) availability of support group; 2) age; 3) length of time on dialysis; 4) internal or external locus of control; 5) and degree of depression and physical symptoms.

In summary, the kidney disease patients suffer from a devastating disease. It is well documented that their working capacity is lower than that of sedentary healthy people. Research has generally found that exercise can be a valuable tool for the treatment and rehabilitation of this population. More systematic research is needed to prepare guidelines for exercise in this population.

MATERIALS AND METHODS

Subjects

The subjects were African-American males on hemodialysis, volunteers from the Baton Rouge area that receive treatment under Dr. McKnight's supervision at the Earl K. Long hospital. A power analysis (alpha <.10) estimated the need for 5 subjects (Freund & Wilson, 1993). Only patients that met the following criteria were included: 1) were 20 to 40 years of age; 2) had a stable kidney disease condition; 3) had no musculoskeletal problem that would impair or hinder their ability to perform physical work; 4) had similar dialysis treatment; 5) controlled hypertension by the same drugs (i.e., procardia, rifadin, metropolol). Patients were excluded if they did not meet our criteria, and if they were on anti-depressant medication.

Protocol

After written consent had been signed, all the subjects were scheduled for a maximal test using a modified Bruce protocol (ACSM, 1988). The determination of VO_2 peak was during the day off dialysis. The reasons for termination of this test were: 1) reaching an R value near or beyond 1.0; 2) blood pressure of 220/120 mmhg. without medication; or 3) the patient expressing the desire to stop (e.g., leg pain or shortness of breath). Then, on separate occasions 3 submaximal tests were performed. The submaximal treatment consisted of a brisk walk on the treadmill for 30 minutes at 60% of VO_2 peak. The subjects were asked to refrain from smoking; ingestion of coffee, tea or carbonated drinks for at least 3 hours prior to their scheduled tests, and were in a postabsorptive state. The predialysis treatment was administered 2 hours before dialysis. The postdialysis treatment was administered 1 hour after dialysis on a different day. The off treatment day was 24 hours after their last dialysis. The testing order was randomly assigned for the three different times.

Variables

The following variables were measured: 1) cardiorespiratory; 2) hematological; and 3) psychological. The cardiorespiratory variables were: 1) peak oxygen consumption (VO_2peak); 2) ventilation (V_E); 3) respiratory exchange ratio (R); 4) oxygen consumption (VO_2); 5) carbon dioxide production (VCO_2); and 6) kilocalories (Kcal/min). The hematological variables were: 1) blood urea nitrogen (BUN); 2) hematocrit (Ht); 3) hemoglobin (Hb); 4) albumin (Al); 5) sodium (Na^{++}); 6) potassium (K^+); 7) total protein (Tp); 8) creatinine (Cr); 9) glucose (Gl); 10) creatine phosphokinase (CPK); 11) lactate dehydrogenase (LDH); and12) ammonia (NH_4). Arterial blood gases tested were: 1) partial pressure of carbon dioxide ($PaCO_2$); 2) partial pressure of oxygen (PaO_2); 3)pH; 4) bicarbonate (HCO_3); and 5) saturation of oxygen (SaO_2). The psychological variables were: 1) Borg's rating of perceived exertion (RPE); 2) Multiple Affect Adjective Check List (MAACL, Zuckerman & Lubin, 1985); and 3) Nonspecific Symptoms Questionnaire (NSQ, Brunnier & Graydon, 1993).

The pulmonary variables were measured every minute for the duration of the test. During the submaximal exercise tests, baseline measurements were collected on the cardiorespiratory, hematological and psychological variables. During the 30-minute submaximal exercise tests, the cardiorespiratory data were collected every 10 minutes (average of 10-, 20-, and 30-minute sample was used for the analysis), and one blood sample was drawn at 15 minutes into the exercise. Upon completion of the 30-minute test, the hematological variables were measured immediately. The hematological and psychological variables were collected after 5 minutes of recovery. Thirty minutes in the recovery, the hematological variables were assessed. The same protocol was used for the three different times: predialysis. postdialysis. and off dialysis.

Equipment and Procedures

The treadmill used for the exercise was a Quinton 5000 Stress Test System model with built in computerized electrocardiogram program. The cardiorespiratory data were collected using the Q-Plex Metabolic Cart (Quinton). The cart was calibrated before each test for volume and gases. In the submaximal sessions. once the patient arrived at the Cardiology Laboratory, the nurse placed a line in the A-V graft for blood drawing. The blood was draw using a 10cc syringe, and was placed in collection tubes with heparin, EDTA or culture gel for analysis. All the hematological assays were conducted by the hematological and biochemistry laboratory at the Earl K. Long with the exception of ammonium (see Appendix D). This assay was performed by the investigator at the biochemistry laboratory in the Department of Kinesiology at Louisiana State University. For the ammonium, a Sigma Chemical Company Kit No. 640 Handbook was used (Appendix E). Upon collection of the blood (12cc), it was divided for the different analyses and immediately sent to the laboratories. The blood for the analysis conducted by the investigator was chilled in water with ice and taken to LSU. The blood for the analysis of blood gases used a special 5cc syringe and was placed in ice for immediate analysis by the respiratory laboratory at the Earl K. Long hospital. They used an Instrumentation Laboratory BG3 System model.

Statistical Analysis

The differences in physiological and psychological responses to different times of exercise were detected using a randomized block design (RBD), where each subject was treated as a block. The significance level for the study was set at .10 for the RBD, and .05 for the post hoc test. A power analysis found that an alpha level of .10 (beta=.50), and n=5 had sufficient power to detect meaningful differences (Dotson & Kirkendall, 1974; Franks & Huck, 1986). The Newman-Keuls test was used as a post hoc test.

RESULTS and DISCUSSION

Nine subjects initially volunteered for the study. Two of these patients withdrew because of lack of commitment, and two because of personal problems. The five subjects that completed the study were all African-American males, with an average age of 32.8 (±8.3) years, average weight of 207.6 (±55.5) lbs, and average height of 67.8 (±3.65) inches. None of them were physically active and they had been on dialysis an average of 4.4 (±4.67) years. All of the patients had hypertension (one was diabetic) and were on medication. Table 1 depicts the characteristics of the subject group.

The peak oxygen consumption (VO_2peak) test used in this study was the Bruce treadmill protocol. The average VO_2peak was 17.34 (±3.72) $ml*kg^{-1}*min^{-1}$ (see table 2). The average R peak value was 1.05 (±0.13), demonstrating that the patients were working near their physiological limit. The values obtained in the test are comparable with those obtained elsewhere (Painter et al., 1986b; Burke et al., 1983).

The statistical analysis of the submaximal cardiorespiratory data showed that there were significant differences in main effect for treatment in the following variables: VO_2 ($p<.10$), VO_2/kg ($p<.01$), and kcal/min ($p<.10$) (Table 3). Post hoc analysis of these variables showed that only VO_2/kg was significant ($p<.05$) when treatments were compared. The VO_2/kg for pre dialysis was different to post dialysis treatment and off dialysis treatment was different from post dialysis treatment.

TABLE 1. SUBJECT CHARACTERISTICS

Ss	AGE (yrs)	WT (lbs)	HT (in)	JOB	PHYS ACTIVE	YEARS HD
001	39	235	72.5	YES	NO	1
002	34	206	66	YES	NO	9
003	41	143	67.5	NO	NO	10
004	30	285	70	NO	NO	1
005	20	169	63	NO	NO	1
MEAN SD	32.8 8.3	207.6 55.5	67.8 3.65			4.4 4.67

Legend:
Ss: Subject
WT: Weight
PHYS ACTIVE: Physically Active
HT: Height
HD: Hemodialysis
SD: Standard Deviation

TABLE 2. VO_2 PEAK TESTS RESULTS

Ss	VO_2PEAK	RPEAK	V_EPEAK	KCAL PEAK
001	16.2	1.25	62.8	8.80
002	21.0	0.96	55.8	9.72
003	20.8	1.14	48.6	7.43
004	12.0	1.02	86.2	8.93
005	16.7	0.91	42.7	6.34
MEAN SD	17.34 3.72	1.05 0.13	59.22 16.86	8.24 1.35

Legend:

Ss: Subject

VO_2= Oxygen Consumption
R= Respiratory Exchange Ratio
V_E= Ventilatory Rate
KCAL= Kilocalories

TABLE 3. MEANS AND STANDARD DEVIATIONS FOR THE CARDIORESPIRATORY VARIABLES

VARIABLE	PRE DIALYSIS	POST DIALYSIS	OFF DIALYSIS	p VALUE	POST HOC**
V_E	23.77(±8.64)	31.75(±1.83)	25.40(±7.92)	.49	
VO_2	0.692(±0.30)	1.09(±0.22)	0.90(±0.37)	.10*	NS
VCO_2	0.562(±0.26)	0.922(±0.15)	0.637(±0.24)	.13	
R	0.80(±0.04)	0.85(±0.04)	0.77(±0.02)	.24	
VO_2/KG	5.99(±3.26)	10.95(±1.24)	7.42(±2.85)	.01*	POST>OFF, PRE
KCAL/MIN	3.35(±1.49)	5.31(±1.01)	3.97(±1.42)	.10*	NS

Legend:

Mean (±Standard Deviation)

* Significant for the Treatment Effect, $p<.10$

** A Greater Than or Less Than Sign (<,>) Indicates a Significant Difference ($p<.05$). A Comma (,) Indicates No Significant Difference in Post Hoc Analysis.

But, there were no differences in VO_2/kg between off and pre. There were no significant differences in main effects for time or interactions (time * treatment).

The results of the randomized block design used to analyze the hematological data are summarized in table 4. There was a difference in main effect for time for glucose ($p<.01$). The post hoc analysis for the effect of time on glucose found that the baseline concentration was significantly higher than the rest of the times (i.e., exercise 15, exercise 30, recovery 5, and recovery 30). There was no other significant change in time. The analyses also showed significant differences for the effect of treatment in the hematological variables: blood urea nitrogen ($p<.01$), creatinine ($p<.01$), total protein ($p<.01$), sodium ($p<.05$), potassium ($p<.01$), LDH ($p<.01$), CPK ($p<.06$), albumin ($p<.01$), bicarbonate ion ($p<.02$), pH ($p<.01$), and ammonium ($p<.02$). The post hoc test (see table 5) revealed that blood urea nitrogen, creatinine, sodium, potassium, total protein, albumin, lactate dehydrogenase, creatine phosphokinase, ammonium, pH, and bicarbonate were significantly different pre vs. post, and post vs. off ($p<.05$); but not in pre vs. off ($p>.05$). LDH and CPK were also significantly different between pre vs. off ($p<.05$). The concentrations of blood urea nitrogen, creatinine, sodium, and potassium were lower at post dialysis compared to pre or off, which were not significantly different from each other.

TABLE 4. RESULTS FORM THE RANDOMIZED BLOCK DESIGN FOR THE HEMATOLOGICAL VARIABLES

VARIABLE	BASELINE	EXERCISE 15m	EXERCISE 30m	REC 5m	REC 30m	MEAN S.D.	TRT	TIME	TRT*T
GLUCOSE							0.25	0.01*	0.86
PRE	109.2 (±21.3)	97.6 (±21.3)	102.0 (±28.9)	97.0 (±21.9)	111.3 (±20.4)	103.0 (±21)			
POST	131.2 (±14.5)	104.0 (±12.4)	99.4 (±16.5)	98.3 (±16.1)	107.8 (±16.3)	108.6 (±18)			
OFF	108.6 (±25.1)	94.0 (±15.7)	91.6 (±19.5)	84.6 (±12.3)	98.5 (±25.7)	96.3 (±20)			
MEAN S.D.	116.3 (±22.0)	97.9 (±16.6)	97.6 (±21.1)	94.3 (±16.3)	105.3 (±19.8)				
BUN							0.01*	0.99	0.89
PRE	60.0 (±10.4)	60.8 (±9.1)	61.2 (±9.1)	60.0 (±10.5)	63.5 (±3.53)	60.45 (±9)			
POST	29.0 (±6.9)	29.8 (±7.2)	30.0 (±7.3)	32.0 (±7.6)	32.0 (±7.8)	30.43 (±7)			
OFF	60.4 (±18.2)	60.0 (±18.6)	60.8 (±18.9)	63.0 (±24.8)	54.3 (±10.4)	59.6 (±16)			
MEAN S.D.	49.8 (±19.3)	49.2 (±19.6)	48.8 (±20.6)	51.4 (±19.1)	47.2 (±15.6)				

table con'd

Na^{++}							0.05*	0.92	0.96
PRE	139.7 (+2.2)	140.2 (±2.0)	140.1 (±2.1)	139.0 (±1.2)	139.8 (±2.6)	139.8 (±2)			
POST	138.5 (±2.1)	138.8 (±1.9)	139.2 (±2.3)	139.0 (±3.2)	139.2 (±2.8)	138.1 (±2)			
OFF	140.4 (±.7)	140.9 (±.7)	141.1 (±.6)	141.3 (±.4)	141.5 (±.5)	141.0 (±.7)			
MEAN S.D.	139.5 (±.9)	139.9 (±1.8)	140.2 (±1.6)	139.7 (±1.3)	140.7 (±2.0)				
K^{+}							0.01*	0.54	0.99
PRE	4.8 (±.4)	5.0 (±.4)	5.0 (±.4)	4.9 (±.5)	5.3 (±.6)	5.00 (±.4)			
POST	3.9 (±.3)	4.2 (±.2)	4.4 (±.2)	4.2 (±.1)	4.4 (±.2)	4.27 (±.2)			
OFF	4.7 (±.4)	4.9 (±.4)	4.9 (±.4)	4.7 (±.1)	4.9 (±0.4)	4.86 (±.3)			
MEAN S.D.	4.5 (±.5)	4.8 (±.5)	4.8 (±.5)	4.6 (±.4)	4.8 (±.5)				

table con'd

CRE							0.01*	0.97	0.71
PRE	15.9 (±3.0)	16.0 (±2.9)	16.2 (±3.1)	16.2 (±3.1)	14.9 (±2.4)	15.9 (±3)			
POST	9.1 (±2.1)	9.3 (±2.0)	9.4 (±2.0)	9.6 (±2.3)	9.4 (±2.2)	9.3 (±2)			
OFF	15.3 (±4.5)	15.4 (±4.4)	15.5 (±4.6)	15.7 (±6.3)	14.2 (±3.6)	15.2 (±4)			
MEAN S.D.	13.4 (±.4)	13.6 (±4.4)	13.7 (±4.5)	14.0 (±4.9)	12.8 (±3.6)				
TOTAL PROTEIN							0.01*	0.89	0.90
PRE	7.4 (±.6)	7.5 (±.6)	7.6 (±.6)	7.5 (±.7)	7.1 (0)	7.5 (±.5)			
POST	8.3 (±.9)	8.3 (±.7)	8.3 (±.8)	8.3 (±.7)	7.7 (±.2)	8.2 (±.7)			
OFF	7.5 (±.2)	7.7 (±.4)	7.6 (±.3)	7.8 (±.2)	7.4 (±.2)	7.6 (±.3)			
MEAN S.D.	7.8 (±.8)	7.9 (±.6)	7.8 (±.7)	7.9 (±.6)	7.5 (±.3)				

table con'd

LDH							0.01*	0.87	0.91
PRE	198.4 (±44.1)	200.2 (±44.9)	190.8 (±36.6)	181.0 (±36.4)	196.6 (±30.5)	193.7 (±37)			
POST	222.4 (±30.9)	226.8 (±40.6)	224.4 (±22.0)	216.8 (±43.4)	228.8 (±12.3)	223.9 (±29)			
OFF	199.0 (±41.3)	210.6 (±46.8)	211.4 (±38.5)	212.0 (±42.0)	217.5 (±23.1)	209.6 (±36)			
MEAN S.D.	206.6 (±38.6)	212.5 (±44.1)	208.8 (±32.4)	203.3 (±40.6)	214.3 (±22.0)				
CPK							0.06*	0.87	0.96
PRE	457.2 (±335.2)	546.6 (±343.1)	471.0 (±345.8)	358.5 (±277)	472.3 (±386)	446.3 (±305)			
POST	439.8 (±320.8)	457.8 (±350.7)	469.4 (±366.7)	496.3 (±414)	539.5 (±361)	477.1 (±328)			
OFF	502.6 (±275.6)	517.2 (±281.2)	525.4 (±283.5)	490.0 (±256)	601.0 (±249)	527.3 (±248)			
MEAN S.D.	466.5 (±311)	507.2 (±325)	488.6 (±332)	448.2 (±316)	537.6 (±332)				

table con'd

ALBUMIN							0.01*	0.96	0.93
PRE	3.86 (±0.1)	3.9 (±.02)	3.9 (±0.1)	3.9 (±0.2)	3.8 (±0.2)	3.96 (±.19)			
POST	4.4 (±0.4)	4.4 (±0.4)	4.3 (±0.4)	4.2 (±0.3)	4.2 (±0.4)	4.22 (±.37)			
OFF	4.0 (±0.1)	4.1 (±0.2)	4.1 (±0.1)	4.0 (±0.1)	4.0 (±0.2)	4.04 (±.30)			
MEAN S.D.	4.08 (±.2)	4.1 (±.2)	4.1 (±.2)	4.0 (±.3)	4.0 (±.3)				
HGB							0.58	0.11	0.32
PRE	11.3 (±1.4)	11.6 (±0.8)	11.9 (±0.9)	12.5 (0)	11.4 (±1.0)	11.62 (±1.0)			
POST	11.8 (±1.7)	12.2 (±0.9)	12.0 (±1.1)	12.2 (±1.5)	11.5 (±0.6)	11.94 (±1.1)			
OFF	11.2 (±.2)	11.3 (±0.1)	11.3 (±0.1)	11.4 (±0.4)	10.9 (±0.4)	11.18 (±.42)			
MEAN S.D.	11.4 (±1.1)	11.7 (±.6)	11.7 (±.7)	12.0 (±1.0)	11.3 (±1.0)				

table con'd

HCT							0.84	0.13	0.26
PRE	35.5 (±3.7)	36.2 (±3.2)	36.6 (±3.2)	37.1 (±0)	36.3 (±1.0)	36.20 (±3.0)			
POST	34.9 (±4.3)	35.1 (±2.2)	36.3 (±3.9)	37.2 (±4.3)	34.0 (±2.7)	35.77 (±3.4)			
OFF	35.8 (±3.0)	34.5 (±1.5)	34.4 (±1.4)	34.9 (±1.3)	34.3 (±0.7)	34.53 (±1.9)			
MEAN S.D.	35.4 (±3.6)	35.3 (±2.3)	35.8 (±2.9)	36.4 (±2.8)	34.9 (±1.5)				
HCO_3							0.02*	0.91	0.97
PRE	24.8 (±1.4)	24.2 (±0.9)	25.0 (±1.7)	25.1 (±1.4)	23.5 (±0.4)	24.71 (±1.4)			
POST	28.4 (±0.8)	28.4 (±1.7)	28.6 (±1.8)	28.6 (0)	28.3 (±0.6)	28.44 (±1.0)			
OFF	25.7 (±3.5)	24.9 (±3.3)	25.8 (±1.8)	24.9 (±3.5)	25.6 (±2.4)	25.47 (±2.3)			
MEAN S.D.	26.3 (±2.0)	26.1 (±2.0)	26.5 (±1.8)	26.2 (±2.5)	25.8 (±1.1)				

table con'd

SaO_2							0.67	0.45	0.91
PRE	97.9 (±1.3)	98.3 (±0.4)	98.2 (±0.8)	97.7 (±1.8)	98.4 (±0.4)	98.07 (±1.0)			
POST	98.7 (±0.7)	98.2 (±0.6)	98.8 (±0.3)	98.1 (0)	98.5 (±0.7)	98.6 (±.55)			
OFF	98.5 (±0.5)	97.9 (±1.1)	98.4 (±1.0)	97.3 (±0.9)	98.1 (±1.4)	98.08 (±1.0)			
MEAN S.D.	98.4 (±.41)	98.1 (±.21)	98.4 (±.31)	97.7 (±.40)	98.3 (±.20)				
PaO_2							0.91	0.64	0.80
PRE	112.8 (±21.6)	114.4 (±9.2)	112.8 (±12.5)	107.8 (±20.9)	113.0 (±3.60)	112.27 (±14)			
POST	127.0 (±19.9)	106.5 (±9.0)	117.0 (±4.2)	104.0 (0)	111.0 (±16.9)	114.90 (±14)			
OFF	118.8 (±15.2)	109.0 (±17.4)	120.3 (±18.8)	98.6 (±15.1)	116.8 (±24.2)	112.94 (±19)			
MEAN S.D.	119.5 (+7.1)	109.9 (+4.0)	116.7 (±3.8)	103.4 (±4.6)	113.6 (±2.9)				

table con'd

$PaCO_2$							0.33	0.79	0.79
PRE	41.4 (±2.8)	41.2 (±2.1)	41.3 (±2.1)	41.1 (±2.5)	38.3 (±0.7)	40.85 (±2.3)			
POST	38.5 (±4.4)	39.4 (±1.1)	39.2 (±2.3)	42.1 (0)	37.7 (±4.3)	39.05 (±3.2)			
OFF	40.2 (±2.7)	41.9 (±4.5)	41.3 (±3.6)	41.1 (±3.6)	40.4 (±12.1)	40.97 (±3.1)			
MEAN S.D.	40.0 (±1.5)	40.8 (±1.3)	40.6 (±1.2)	41.4 (±.58)	38.8 (±1.4)				
pH							0.01*	0.90	0.98
PRE	7.37 (±0.03)	7.37 (±0.03)	7.38 (±0.03)	7.39 (±0.02)	7.39 (±0.01)	7.383 (±.02)			
POST	7.47 (±0.05)	7.46 (±0.04)	7.47 (±0.06)	7.43 (0)	7.48 (±0.06)	7.467 (±.04)			
OFF	7.40 (±0.05)	7.38 (±0.04)	7.40 (±0.03)	7.38 (±0.03)	7.40 (±0.03)	7.398 (±.03)			
MEAN S.D.	7.41 (±.05)	7.42 (±.06)	7.43 (±.06)	7.40 (±.02)	7.42 (±.05)				

table con'd

NH_4							0.02*	0.93	0.97
PRE	0.13 (±0.2)	0.14 (±0.1)	0.10 (±0.08)	0.18 (±0.1)	0.07 (±0.02)	0.138 (±.12)			
POST	0.17 (±.14)	0.24 (±.18)	0.26 (±.26)	0.14 (±.16)	0.12 (±.18)	0.189 (±.17)			
OFF	0.20 (±0.1)	0.14 (±0.1)	0.11 (±0.1)	0.12 (±0.1)	0.07 (±0.01)	0.134 (±.12)			
MEAN S.D.	0.16 (±.04)	0.17 (±.05)	0.16 (±.08)	0.15 (±.03)	0.08 (±.02)				

Legend: * Significant at $p<.10$

TABLE 5. RESULTS FROM NEWMAN-KEULS POST HOC TEST FOR TREATMENT: HEMATOLOGICAL VARIABLES

VARIABLE	PRE to POST	POST to OFF	PRE to OFF
HEMATOLOGICAL:			
BLOOD UREA NITROGEN	* -30	* +29	NS
CREATININE	* -6.5	* +8.7	NS
SODIUM	* -1.8	* +3	NS
POTASSIUM	* -.7	* +.6	NS
TOTAL PROTEIN	* +.7	* -.6	NS
ALBUMIN	* +.3	* -.2	NS
LDH	* +30	* -14	* -16
CPK	* +31	* +50	* -81
AMMONIUM	* +.05	* -.05	NS
pH	* +.08	* -.07	NS
BICARBONATE	* +3.7	* -2.9	NS

Legend:
NS= Non significant
* Significant at $p<.05$

This trend was expected since the highest accumulation of these substance occurs before dialysis. The dialysis will eliminate most of the blood urea nitrogen and creatinine and will balance the electrolytes. The total protein, albumin, ammonium, pH, and bicarbonate had the highest concentration at post with no significant change between off and pre. The ammonium, pH, and bicarbonate also followed the preceding trend. These patients suffer from metabolic acidosis. As time goes on without dialysis, the pH will change to become more acidic. Then, the bicarbonate and the ammonium will work together to maintain a balanced pH. There was no significant treatment effect for glucose ($p<.25$), hematocrit ($p<.84$), hemoglobin ($p<.58$), pCO_2 ($p<.33$), pO_2 ($p<.91$), and SaO_2 ($p<.67$).

In terms of the psychological data, the analysis of variance showed that the following symptoms had significant differences for the main effect of time (see table 6): shortness of breath ($p<.02$), joint pain ($p<.02$), cramps ($p<.02$), and muscle weakness ($p<.10$). The subjects had these symptoms before they performed the exercise protocol. When they finished the exercise protocol, they were asymptomatic. No significant treatment effect were found for the physical symptoms. In the Multiple Affect Adjective Checklist, depression had significant differences for the effect of treatment ($p<.03$). The post hoc test revealed differences in the scores for the mood of depression between post and off ($p<.05$), but not between pre vs. off or pre vs. post. No other differences were found in the MAACL. The analysis of the RPE data showed no differences in time or treatment.

TABLE 6. FREQUENCIES FOR THE NON-SPECIFIC SYMPTOMS QUESTIONNAIRE

	BASELINE			POST EXERCISE			P-VALUE		
VARIABLES	PRE	POST	OFF	PRE	POST	OFF	TRT	TIME	TRT*TIME
SYMPTOMS:									
SHORTNESS OF BREATH	2	1	1	0	0	0	0.66	0.02*	0.66
JOINT PAIN	2	2	0	0	0	0	0.18	0.01*	0.18
CRAMPS	1	2	1	0	0	0	0.66	0.02*	0.66
MUSCLE WEAKNESS	1	1	1	0	0	0	1.0	0.09*	1.0
SLEEP DISTURBANCES	2	2	1	0	0	1	0.74	0.12	0.43
ITCHING	0	1	1	0	0	0	1.0	0.12	1.0
HEADACHE	1	0	0	0	1	0	0.54	1.0	0.18
CHEST PAIN	1	0	0	0	0	0	0.39	0.33	0.39

Legend: * Significant at $p<.10$

TABLE 7. MEANS AND STANDARD DEVIATIONS FOR THE MAACL

	BASELINE				POST EXERCISE				P-VALUE		
VARIABLES	PRE	POST	OFF	M ±SD	PRE	POST	OFF	M ±SD	TRT	TIME	TRT*T
MAACL:											
HOSTILITY	0.50 (±1.0)	0.50 (±1.0)	0	.50 (0)	0	0	0	0	0.54	0.13	0.54
ANXIETY	1.75 (±1.5)	0.75 (±1.5)	0.25 (±0.5)	.92 (±.7)	0.75 (±0.5)	0.50 (±1.0)	0.50 (±0.5)	.58 (±.1)	0.11	0.15	0.11
DEPRESSION	0	0.75 (±0.5)	0	.25 (±.4)	0.25 (±0.5)	1.0 (±1.4)	0	.41 (±.5)	0.02*	0.52	0.89
POSSITIVE AFFECT	16.75 (±2.4)	16.0 (±3.8)	18.0 (±2.2)	16.9 (±1.0)	16.75 (±2.9)	15.5 (±3.8)	16.5 (±5.3)	16.3 (±.6)	0.44	0.49	0.81
SENSATION SEEKING	7.5 (±2.1)	5.0 (±3.5)	5.25 (±2.2)	5.9 (±1.4)	7.0 (±2.6)	7.0 (±0.8)	5.75 (±1.7)	6.7 (±.7)	0.37	0.54	0.50

Legend: *Significant at p<.10

M±SD: Mean±Standard Deviation

Discussion

The purpose of the present study was to determine the cardiorespiratory, hematological, and psychological responses to submaximal exercise and recovery in hemodialysis patients at three different times (pre dialysis, post dialysis, and off dialysis).

This study demonstrated that dialysis patients can exercise safely as determined by the cardiorespiratory, hematological and psychological responses. The data showed that some of the variables reached an abnormal level, but the patients were able to exercise without complications. For example, the concentrations of K^+ (range: 4.27-5.0), total protein (range: 7.46-8.19), LDH (range: 193- 223), and CPK (range: 446-527) were above the normal range. These dialysis patient were able to make the necessary adaptations to perform the exercise.

Other investigators had found higher values for K^+ than those of this study (Daul, et al., (1995) range: 5.3-6.1 mmol/l; Burke, et al., (1984) average: 5.2$\pm$1.0 mmol/l). The normal blood concentration of K^+ is 3.40-4.80 mmol/l. When the K^+ level reaches a critical level above 6 mmol/l, the person is exposed to the risk of a dangerous cardiac accident. High levels of K^+ can cause significant dysrhythmias, therefore is necessary to take into account that K^+ levels will increase with exercise and that between dialysis sessions the concentration also increases.

In this study, only subject # 5 reached that critical level of K^+ during exercise in the pre dialysis treatment. Therefore, exercise before dialysis might not be appropriate for some dialysis patients.

The normal range for Na^{++} concentration is between 137-149 mmol/l. Our patients' range was between 138.06-141 mmol/l, which is comparable with those found elsewhere (Lundin et al. 1987, Na^{++}: 138.6-142.1). The average sodium concentration was significantly lower post as compared to pre or off, with these latter values not being significant. Sodium concentration is an important factor in the regulation of extracellular fluid. A decrease in sodium implies volume depletion, and an increase in volume concentration implies volume overload. The importance of sodium and fluid balance derives from the complications of volume overload, which can have serious complications including edema, pericarditis, hypertension, and congestive heart failure. In addition, the changes in total protein and albumin might reflect changes in fluid balance. Both total protein and albumin, followed the same direction (highest post, off, lowest pre), which is inversely related to weight gains due to volume overload. Therefore, these changes provide evidence that supports the hypothesis of increased physiological stress form pre to off to post.

The levels of BUN and creatinine reflect the amount of protein metabolism. The kidneys are responsible for their elimination. Accumulation of these nitrogenous waste products are thought to cause the symptoms in uremia. Also, high levels can lead to glomerular and arterial hypertension. Normal ranges for BUN are 5-25 mg/dl, and for creatinine 0.5-1.4 mg/dl. Our patients' average ranges were substantially higher: 30.43-60.45 mg/dl for BUN, and 9.32-15.88 mg/dl for creatinine. The post treatment was significantly lower as compared to pre and off (which were not significantly different). Even after dialysis the levels of BUN and creatinine were above the upper limit of normal range (BUN: 30.43; creatinine: 9.32). The importance of BUN and creatinine removal with dialysis is to help alleviate the symptoms produced by their accumulation (Brenner & Rector, 1977). These data supports the hypothesis of increased physiological stress from pre to off to post.

The kidney removes about 50 to 100 mEq/day of acid produced by metabolism of dietary protein (Tolkoff-Rubin & Pascual, 1994). Chronic acidosis (pH< 7.3) produces symptoms of fatigue, lethargy, increases respiratory work, catecholamines responsiveness, and stimulates protein degradation. The highest average for pH was found after dialysis (7.467, basic), then off (7.398), and pre (7.383, acidic). Post was significantly different from pre and off. The subjects were able to handle the changes in pH without adverse consequences during the exercise treatments. The other variables that have an effect on pH--ammonium and bicarbonate had the following trend: bicarbonate--highest post. off and pre. and ammonium--highest post, pre. off. Therefore, as acidic conditions developed in the kidney patients, they rely more on the ammonium and bicarbonate to maintain pH balance. Therefore, these changes provide partial support for the hypothesis that there is higher physiological stress pre followed by off and post.

In the present study, the values obtained for blood gases, specifically for PaO_2, and $PaCO_2$, were higher than those reported elsewhere for the kidney patients (Lewis, et al. 1992; Burke, et al., 1984). There are several factors that would affect the behavior of these gases including temperature, pH, and 2-3 DPG. The exercise was conducted in a thermoneutral environment. Metabolic acidosis will cause a reduction in affinity of the hemoglobin with oxygen causing unloading of oxygen (saturation). The post dialysis treatment contained the highest value for pH (7.46 ± 0.5), and for PaO_2 (114.9 ± 14.4). A value of 7.46 does not represent acidotic conditions, thus the reason why the arterial pressure of oxygen is that high remains unclear. These values are comparable with the reports of others for pH (Barnea, et al.1980, pH:7.43; Lewis, et al. 1992, pH:7.42). But the value found in this study for PaO_2 and $PaCO_2$ is higher than those reported by Lewis et al. 1992 (PaO_2: 106 ± 11; $PaCO_2$: 38.6). These patients were anemic, well below the normal range (normal Hct: 42-52, patients: 34-36; normal Hgb: 14-18, patients: 11.18-11.62). The patients were able to exercise at 60% of maximal capacity for 30 minutes without complication at three different times even with low oxygenation capacity.

The cardiorespiratory variables reflected normal increases in VO_2, VCO_2, and R to exercise. The values obtained for these variables followed the trend of the highest value at post, then off, and pre. This supports the hypothesis that specifies that with high levels of stress (increased metabolites), the cardiorespiratory regulation is impaired. The values obtained in this study were lower than those reported elsewhere. Burke et al. (1983), found an average V_E value of 35.3, and VO_2 of 1.45, whereas in the study the values found were: V_E:23.77-31.75, and VO_2:.692- 1.09 for the same relative intensity, indicating the patients in this study had a higher fitness level. The respiratory exchange ratio was similar to those found elsewhere (this study range: .77-.85 vs. Lewis et al., 1992: .81). There are reports of hypotensive episodes after dialysis (Painter, et al. 1986b), however no episode of hypotension was observed in this study. These data provide support for the hypothesis of high physiological stress from pre to off to post.

In the psychological data, there were differences in the time effect for physical symptoms (sleep disturbances, joint pain, muscle weakness, shortness of breath, and cramps). There were significant changes from before to after the exercise was performed.

After exercise the patients felt better than before the exercise. There were a non- significant trend for the symptoms to be highest pre, post, and the lowest off. This study found that the physical symptoms improved with exercise.

In the MAACL, only the scores for the mood of depression was found to be different. Interestingly, their score for the mood of depression was higher after dialysis treatment than on the day off. A possible explanation is that they expend 3 to 4 hours on dialysis in a center where all the people are very sick which does not represent an encouraging picture to the subjects. Although anxiety was found not to be significant ($p=.11$), anxiety and depression both had the lower score on the off treatment. These psychological responses indicate how much mental stress dialysis can cause. Maher, et al. (1983) identified several sources of stress in this population. One of the sources of stress is that derived from the demands of dialysis. Once the patients finish their treatment they can go home and continue their daily routines. But, three times a week for at least 3 hours is a lot of time in a negative environment. Maher, et al. (1983) found that patients who had been on dialysis less than two years had greater depression that patients who had been on dialysis for about a year. Three out of five subjects in this study had been on dialysis a longer time period. Thus, the differences in the scores for the mood of depression can be accounted by the time that subjects had been on dialysis. Biddle (1992) found that depression improves with exercise (acute and chronic) in healthy individuals. Shalom et al. (1984) found that exercise training improved the scores of the depression for the patients that participated in at least half of the sessions, but failed to show improvement when all the participants were taken into account. The depression response was not expected, since the investigator hypothesized that after dialysis the patients would feel better and therefore they would have the lower scores in the depression scale. Nevertheless, this finding can be used to schedule exercise sessions that will improve adherence. Therefore, this finding rejects the hypothesis that the lowest psychological scores for depression are found post dialysis.

In conclusion, this study showed that this group of dialysis patients can exercise safely at 60% of their VO_2peak, and that exercise can ameliorate some of the physical symptoms. The post dialysis exercise resulted in better hematological and cardiorespiratory response to exercise, but dialysis caused increased scores for depression. Pre-dialysis exercise showed the highest physiological stress illustrated by the hematological and cardiorespiratory data.

The time relationship to dialysis is a stronger influence on the hematological variables than acute exercise. The changes in the variables seen as result of the acute exercise reflect more the disease state of the patients. An exception was glucose, where the exercise caused significant changes in concentration. The effects of acute exercise have a stronger influence on symptoms than the time relationship to dialysis. During the three exercise treatments, the patients had a range of symptoms. But, the exercise tended to improve those symptoms. The time relationship to dialysis has little influence on psychological variables. The score for the mood of depression scores were found higher after dialysis.

We should be very cautious in extending these recommendations to the general kidney disease population. Our subjects have distinct characteristics that might differ from the average kidney patient. They were a young group, with "overall" better health than the rest of the population. Although they did not meet our criteria for "physically active" (at least 20 min., 3 times per week), two of them held full time jobs, and the others were somewhat active.

SUMMARY AND CONCLUSIONS

The purpose of this study was to determine the cardiorespiratory, hematological and psychological responses to acute submaximal exercise and recovery prior to, following, and on the day off dialysis in hemodialysis patients. Five African-American male subjects on hemodialysis were used for this study. The average age was 32.8 (range: 20-41). The study consisted of a submaximal treadmill exercise (at 60% of VO_2peak) on three different occasions (pre dialysis, post dialysis, off dialysis). The variables measured were grouped in three categories: cardiorespiratory, hematological, and psychological. The cardiorespiratory variables included: ventilation, respiratory exchange ratio, oxygen consumption, and carbon dioxide production. The hematological variables were: blood urea nitrogen, hematocrit, hemoglobin, albumin, sodium, potassium, total protein, creatinine, glucose, creatine phosphokinase, lactate dehydrogenase, and ammonia. Arterial blood gases were also tested, which included: partial pressure of oxygen, partial pressure of carbon dioxide, bicarbonate, pH, and saturation of oxygen. The psychological variables were: Borg's rating of perceived exertion, Nonspecific Symptoms Questionnaire, and the Multiple Affect Adjective Checklist.

It was hypothesized that dialysis patients with the characteristics of this subject group can exercise safely as indicated by acceptable levels of K^{+}, Na^{++}, blood urea nitrogen, creatine and glucose. The second hypothesis stated that the submaximal exercise in the dialysis patients will result in increasing levels of stress form pre to off to post dialysis. Finally, the third hypothesis stated that different degrees of uremic state will have an effect on mood and physical symptoms, with higher scoring on the scales for anxiety, hostility, depression, and physical symptoms from pre to off to post dialysis. The statistical analysis used was a randomized block design with alpha set at $p<.10$. The post hoc test used was Newman-Keuls test (alpha: $p<.05$).

The cardiorespiratory data analysis showed that there were significant differences in the main effect for treatment in the following variables: VO_2 ($p<.10$), VO_2/kg ($p<.01$), and kcal/min ($p<.10$). Post hoc analysis showed that VO_2/kg was higher at post, than off and pre. The analysis for the hematological variables showed that glucose had a significant time effect. The baseline concentration of glucose was significantly higher than the other times. There were significant differences for the effect of treatment in the following variables: BUN ($p<.01$), Cr ($p<.01$), Na^{+} ($p<.05$), K^{+} ($p<.01$), pH ($p<.01$), LDH ($p<.01$), CPK ($p<.06$), and HCO_3 ($p<.02$). The BUN, Cr, Na^{+},and K^{+} had the highest concentration pre as compared to off or post. The highest concentration for pH, and HCO_3 was found to be at post as compared to off or pre. The post hoc analysis revealed that the differences were pre vs. post, and post vs. off in the aforementioned variables. LDH and CPK were also significant in pre vs. off.

The psychological analysis showed that there was a time effect for the following physical symptoms: shortness of breath ($p<.02$), joint pain ($P<.02$), cramps ($p<.02$) and muscle weakness ($p<.10$). The exercise relieved the symptoms. In the MAACL, the scores for the mood of depression had a significant treatment effect. The highest score was found at post, than pre and off, with the post vs. off being significantly different.

In conclusion, young, relatively healthy dialysis patients can safely exercise at 60% of their VO_2peak, without complications. The time relationship to dialysis is a stronger influence on the hematological variables than acute exercise. The effects of acute exercise have a stronger influence on physical symptoms than the time in relationship to dialysis. The time in relationship to dialysis has little influence on the psychological variables. There is more physiological stress the longer the time off dialysis. The process of dialysis has a detrimental effect on the mood for depression even when the patient is strongest physiologically.

The kidney disease patients should be encouraged to exercise for the acute psychological effects and the long term physiological effects. The best time to exercise for the kidney disease patients depends on several factors. The patients that have controlled hypertension, stable kidney disease conditions, no apparent musculoskeletal problem, and pass a graded stress test can exercise at any time. For the patients that do not meet the aforementioned criteria, we should be more cautious in the recommendation. This study found that post dialysis, the patients were more physiologically apt to exercise supported by our findings in the changes in the hematological variables.

Future research in this area should determine the responses to exercise training at different times in kidney disease patients. Also, determine the effect that exercise has 24 hours, 72 hours after completion. These studies will help us understand the long term physiological, and psychological changes in kidney disease patients, as well as adherence.

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APPENDIX A. NON SPECIFIC SYMPTOMS QUESTIONNAIRE

Appendix B

<u>Symptom Scale to Measure Nonspecific Uremic Symptoms</u>

Below are a number of symptoms which people with kidney disease on hemodialysis may experience. Please indicate how frequently you have experienced these symptoms in the past week by circling the appropriate number.

	Never	Rarely	Some-times	Almost Always	Always
Headaches	1	2	3	4	5
Cramps	1	2	3	4	5
Itching	1	2	3	4	5
Short of Breath	1	2	3	4	5
Chest Pain	1	2	3	4	5
Sleep Disturbance	1	2	3	4	5
Joint Pain	1	2	3	4	5
Muscle Weakness	1	2	3	4	5
Nausea/ Vomiting	1	2	3	4	5
Abdominal Pain	1	2	3	4	5

APPENDIX B. MULTIPLE AFFECT ADJECTIVE CHECKLIST

A PA O SS H

1 ☐ active
2 ☐ adventurous
3 ☐ affectionate
4 ☐ afraid
5 ☐ agitated
6 ☐ agreeable
7 ☐ aggressive
8 ☐ alive
9 ☐ alone
10 ☐ amiable
11 ☐ amused
12 ☐ angry
13 ☐ annoyed
14 ☐ awful
15 ☐ bashful
16 ☐ bitter
17 ☐ blue
18 ☐ bored
19 ☐ calm
20 ☐ cautious
21 ☐ cheerful
22 ☐ clean
23 ☐ complaining
24 ☐ contented
25 ☐ contrary
26 ☐ cool
27 ☐ cooperative
28 ☐ critical
29 ☐ cross
30 ☐ cruel
31 ☐ daring
32 ☐ desperate
33 ☐ destroyed
34 ☐ devoted
35 ☐ disagreeable
36 ☐ discontented
37 ☐ discouraged
38 ☐ disgusted
39 ☐ displeased
40 ☐ energetic
41 ☐ enraged
42 ☐ enthusiastic
43 ☐ fearful
44 ☐ fine
45 ☐ fit
46 ☐ forlorn
47 ☐ frank
48 ☐ free
49 ☐ friendly
50 ☐ frightened
51 ☐ furious
52 ☐ lively
53 ☐ gentle
54 ☐ glad
55 ☐ gloomy
56 ☐ good
57 ☐ good-natured
58 ☐ grim
59 ☐ happy
60 ☐ healthy
61 ☐ hopeless
62 ☐ hostile
63 ☐ impatient
64 ☐ incensed
65 ☐ indignant
66 ☐ inspired
67 ☐ interested
68 ☐ irritated
69 ☐ jealous
70 ☐ joyful
71 ☐ kindly
72 ☐ lonely
73 ☐ lost
74 ☐ loving
75 ☐ low
76 ☐ lucky
77 ☐ mad
78 ☐ mean
79 ☐ meek
80 ☐ merry
81 ☐ mild
82 ☐ miserable
83 ☐ nervous
84 ☐ obliging
85 ☐ offended
86 ☐ outraged
87 ☐ panicky
88 ☐ patient
89 ☐ peaceful
90 ☐ pleased
91 ☐ pleasant
92 ☐ polite
93 ☐ powerful
94 ☐ quiet
95 ☐ reckless
96 ☐ rejected
97 ☐ rough
98 ☐ sad
99 ☐ safe
100 ☐ satisfied
101 ☐ secure
102 ☐ shaky
103 ☐ shy
104 ☐ soothed
105 ☐ steady
106 ☐ stubborn
107 ☐ stormy
108 ☐ strong
109 ☐ suffering
110 ☐ sullen
111 ☐ sunk
112 ☐ sympathetic
113 ☐ tame
114 ☐ tender
115 ☐ tense
116 ☐ terrible
117 ☐ terrified
118 ☐ thoughtful
119 ☐ timid
120 ☐ tormented
121 ☐ understanding
122 ☐ unhappy
123 ☐ unsociable
124 ☐ upset
125 ☐ vexed
126 ☐ warm
127 ☐ whole
128 ☐ wild
129 ☐ willful
130 ☐ wilted
131 ☐ worrying
132 ☐ young

APPENDIX C. RESEARCH CONSENT FORM
LOUISIANA STATE UNIVERSITY-BATON ROUGE CAMPUS

1.Study Title: Physiological and Psychological Responses to Submaximal Exercise in Renal Disease Patients

2.Performance Site: Department of Internal Medicine, Earl K. Long Medical Hospital

3.Investigators:

The following medical investigators are available for questions at the 24 hours phone access below.

* Dr. B.D. Franks, Chair
Kinesiology Department, Louisiana State University
388-2036

* Marta Amaral-Melendez, M.S.
Kinesiology Department, Louisiana State University
388-2036

* Dr. G.T. McKnight, M.D.
Clinical Professor of Medicine
Earl K. Long Hospital
358-3941

4.Purpose of the Study:

This study will find the effects of exercise on patients that have kidney disease.

5.Patient Inclusion:

The study will use patients who have kidney disease, and patients that are on dialysis. The participants will be African-American males between the ages of 18 to 40 years of age; who are in stable condition, who have controlled high blood pressure, and can exercise.

6.Patients Exclusion:

Only patients whose doctors agree that they can participate will be eligible. Patients who are not African-American males, or between 18 to 40 years of age will be excluded. Also, patients with uncontrollable high blood pressure will be excluded.

7.Description of the Study:

Dialysis Patients

This study will ask you to walk or jog on a treadmill for 10 to 30 minutes. You will come four different days.

The first session you will walk or jog until you get tired. This means that when you cannot longer keep up with the treadmill speed, we will stop. Therefore, the time is going to vary from one person to another. Also, in this session you will be connected to a machine, through your mouth. You are going to breath through your mouth into a hose, that will take the air into a machine to read the contents of your breath. This whole session is going to take 1 hour.

In the other 3 sessions, you are going to exercise for 30 minutes at a very low speed. This time, not only you are going to be hooked up to the machine that analyzes your breath, but also a nurse is going to draw some blood at 5 different times. The blood is going to be draw one time before the exercise, 2 times while exercising, and 2 times after the exercise is completed. Also, you need to answer 2 questions about how you feel (3 times: one before exercise, one right after exercise is completed and one 1 hour later). This session takes about 2 hours, because after you finish the exercise, you are going to stay for 1 hour.

For the blood draw, a nurse is going to install a catheter in one of your veins. And then blood is going to be draw from the catheter, so you will be stuck one time ONLY. This a simple, safe, harmless, and painless procedure.

In summary, this study will ask you to:

1.come to the hospital 4 separate days
2.exercise on a treadmill (walk or jog) for at least 30 minutes
3.donate some blood during one of the exercise session (5 times)
4.come for one day for 1 hour and the other days for 2 hours

8.Benefits:

This study will provide information necessary about the use of exercise in kidney disease patients. Exercise has been shown to improve quality of life in dialysis patients. It is hoped that the patients, once it is demonstrated that exercise is good for them, will be motivated to participate in an exercise program. Also, this study will provide important information to your doctor about how to prevent, manage and treat kidney disease.

9.Risks:

The work required in all sessions is sufficient to produce some degree of tiredness. The risk involved with exercise include the possibility of a heart attack, but this risk is small and the investigators will have never ask you to participate if they consider that you are not able to exercise. All the exercise sessions will be done in the Department of Cardiology, with physician and EKG monitoring. This is considered a safe procedure. Also, there are some risks involved with the drawing of blood. Among these risks are: slight discomfort, bruising at the site of injection, and slight risk of infection (minimized by the use of a trained phlebotomists).

10.Alternatives:

Risks cannot be reduced further.

11.Removal:

Once the patients finish all the exercise sessions, they will have completed the study.

12.Right to Refuse:

Patients may CHOOSE NOT to participate or withdraw from the study at any time with no penalty and will not risk their treatment at the present time or in the future.

13.Privacy:

The results of the study may be published. The privacy of participating patients will be protected and the identity of participants will not revealed.

14.Release of Information:

The medical records for patients in this study may be reviewed by investigators, but patient identity will be kept secret.

15.Financial Information:

We do not accept any monetary responsibility in the event of a follow up treatment for the patient as a consequence of participating in the study. The patient will accept the responsibility for any treatment that may be required during and/or after their participation in the study.

16.Signatures:

The study has been discussed with me and all my questions have been answered. I understand that additional questions regarding the study should be directed to investigators listed above. I understand that if I have questions about subject rights, or other concerns, I can contact the Vice Chancellor of the LSU Office of Research and Economic Development at 388-5833. I agree with the terms above and I have been given a copy of the consent form.

Signature of the Patient____________________ Date___________

Witness_____________________ Date___________

Investigator(s)_______________________ Date___________

The study subject has indicated to me that the subject is unable to read. I certify that I have read this consent form to the subject and explained that by completing the signature line above the subject has agreed to participate.

Signature of the Reader___________________ Date___________

ADENDUM- RESEARCH CONSENT FORM

Description of the Study

Pre dialysis

This study will ask you to walk or jog on a treadmill for 10 to 30 minutes. You will come four different days.

The first session you will walk or jog until you get tired. This means that when you cannot longer keep up with the treadmill speed, we will stop. Therefore, the time is going to vary from one person to another. Also, in this session you will be connected to a machine, through your mouth. You are going to breath through your mouth into a hose, that will take the air into a machine to read the contents of your breath. This whole session is going to take 1 hour.

In the other 3 session, you are going to exercise for 30 minutes at a very low speed. This time, not only you are going to be hooked up to the machine that analyzes your breath, but also a nurse is going to draw some blood at 5 different times. The blood is going to be draw one time before the exercise, 2 times while exercising, and 2 times after the exercise is completed. Also, you need to answer 2 questions about how you feel, mood and symptoms (3 times: one before exercise, one right after exercise is completed and one 1 hour later). This session takes about 2 hours, because after you finish the exercise, you are going to stay for 1 hour.

For the blood draw, a nurse is going to install a catheter in one of your veins and another one in your dialysis graft for arterial. And then blood is going to be draw from the catheter, so you will be stuck two times ONLY. The total amount of blood that will be drawn is 12 cc. This a simple, safe, harmless, and painless procedure.

In summary, this study will ask you to:

1.come to the hospital 4 separate days
2.exercise on a treadmill (walk or jog) for at least 30 minutes
3.donate some blood during one of the exercise session (5 times)
4.come for one day for 1 hour and the other day for 2 hours

8.Benefits:

This study will provide information necessary about the use of exercise in kidney disease patients. Exercise has been shown to improve quality of life in dialysis patients. It is hoped that the patients, once it is demonstrated that exercise is good for them, will be motivated to participate in an exercise program. Also, this study will provide important information to your doctor about how to prevent, manage and treat kidney disease.

9.Risks:

The work required in all sessions is sufficient to produce some degree of tiredness. The risk involved with exercise include the possibility of a heart attack, but this risk is small and the investigators will have never ask you to participate if they consider that you are not able to exercise. All the exercise sessions will be done in the Department of Cardiology, with physician and EKG monitoring. This is considered a safe procedure. Also, there are some risks involved with the drawing of blood. Among these risks are: slight discomfort, bruising at the site of injection, and slight risk of infection (minimized by the use of a trained phlebotomists).

10.Alternatives:

Risks cannot be reduced further.

11.Removal:

Once the patients finish all the exercise sessions, they will have completed the study.

12.Right to Refuse:

Patients may CHOOSE NOT to participate or withdraw from the study at any time with no penalty and will not risk their treatment at the present time or in the future.

13.Privacy:

The results of the study may be published. The privacy of participating patients will be protected and the identity of participants will not revealed.

14.Release of Information:

The medical records for patients in this study may be reviewed by investigators, but patient identity will be kept secret.

15.Financial Information:

We do not accept any monetary responsibility in the event of a follow up treatment for the patient as a consequence of participating in the study. The patient will accept the responsibility for any treatment that may be required during and/or after their participation in the study.

16.Signatures:

The study has been discussed with me and all my questions have been answered. I understand that additional questions regarding the study should be directed to investigators listed above. I understand that if I have questions about subject rights, or other concerns, I can contact the Vice Chancellor of the LSU Office of Research and Economic Development at 388-5833. I agree with the terms above and I have been given a copy of the consent form.

Signature of the Patient______________________ Date____________

Witness_______________________ Date____________

Investigator(s)_________________________ Date____________

The study subject has indicated to me that the subject is unable to read. I certify that I have read this consent form to the subject and explained that by completing the signature line above the subject has agreed to participate.

Signature of the Reader_____________________ Date____________

APPENDIX D. REFERENCES FOR THE LABORATORY PROCEDURES BY THE EARL K. LONG MEDICAL HOSPITAL

SYNCHRON CX4 AND CXR5 SYSTEMS: INSTRUMENT CODE #876

ANALYTE	METHOD PRINCIPLE
ALBUMIN (g/dl)	DYE BINDING-BROMCRESOL PURPLE
CREATININE (mg/dl)	KINETIC ALKALINE PICRATE (JAFFE)
GLUCOSE (mg/dl)	GLUCOSE OXIDASE (O_2ELECTRODE)
POTASSIUM (mmol/L)	ION SELECTIVE ELECTRODE (DILUTED)
PROTEIN, TOTAL (g/dl)	BIURET
SODIUM (mmol/L)	ION SELECTIVE ELECTRODE (DILUTED)
UREA (mmol/L)	UREASE WITH GLDH (COUPLED ENZYMES)
LDH (IU/L)	BECKMAN SYNCHRON SYSTEMS, 37^0
CPK (IU/L)	BECKMAN SYNCHRON SYSTEMS, 37^0

APPENDIX E. PROCEDURES FOR THE ANALYSIS OF AMMONIUM

Reference

Sigma Chemical Company Kit No 640 Handbook

Principle

Ammonia reacts with phenol and sodium hypochlorite in an alkaline medium to form blue indophenol. Sodium nitroprusside catalyzes the reaction.

Reagents

1 Ammonia-free Water

mix

a. 1 liter deionized dH_2O

b. 40 g DOWEX-50W Strongly Acidic Cation Exchanger (Sigma #50x8-400)

Put the above into a jar which can be tightly sealed

Shake for one minute.

Allow to sit for 24 hours

Be careful not to disturb DOWEX when decanting water

2 Phenol nitroprusside solution (Sigma #640-1)

stored in refrigerator

3 Alkaline hypochlorite solution (Sigma #640-3)

stored in refrigerator

4 *Ammonia Stock Solution* (10 mM)

mix

a. 53 5 mg ammonium chloride (NH_4Cl)

b. 100 ml NH_3-free dH_2O

store in refrigerator

5 Ammonia Standards

a. 80µM

mix. 20 µl ammonia stock

2.48 ml NH_3-free dH_2O

b. 160 µM

mix. 40 µl ammonia stock

2.46 ml NH_3-free dH_2O

c. 300 µM

mix. 75 µl ammonia stock

2.425 ml NH_3-free dH_2O

Sample Preparation

1 Keep blood sample on ice immediately following blood draw. Centrifuge in the cold (5°C minimum) to obtain plasma within 30 minutes. Freeze or analyze plasma immediately

a. The longer blood or plasma is allowed to be warm, the greater chance that any glutamine in the sample will convert to glutamate and thus increase [NH_3]

b. IF USING HEPARIN MAKE SURE THAT IT IS NOT NH_3-HEPARIN.

NH_3-HEPARIN IS MOST COMMONLY FOUND IN CAPILLARY TUBES.

Sample Analysis

1 Set up cuvettes in duplicate in the following manner

Reagents	Blanks	Standards	Unknowns
NH_3-free dH_2O	200 µl	------------	------------
Standard	--------	200 µl	------------
Plasma	--------	------------	200 µl
Phenol Nitroprusside	200 µl	200 µl	200 µl
Alkaline Hypochlorite	200 µl	200 µl	200 µl

2 Incubate 15 minutes at 37°C (Place in 37°C water bath)

3 After 15 minutes add 1 0 ml NH_3-free dH_2O to each cuvette

4 Mix by gentle inversion, and incubate an additional 15 minutes at 37°C

5 Read O D (absorbance) at 630 nm. (Color is stable for at least one hour)

APPENDIX F. DATA COLLECTION CHECKLIST

SUBJECT CODE:__________ WEIGHT:__________
EXERCISE TREATMENT:_____________ DATE:__________

DATA COLLECTION CHECKLIST

BASELINE

CARDIORESPIRATORY _______

HEMATOLOGICAL _______

PSYCHOLOGICAL _______

EXERCISE BEGINS (0 MINUTES)

CARDIORESPIRATORY _____ 10

_____ 20

_____ 30

HEMATOLOGICAL _____ 15

_____ 30

EXERCISE ENDS
RECOVERY (5 MINUTES)

HEMATOLOGICAL _____

PSYCHOLOGICAL _____

RECOVERY (30 MINUTES) HEMATOLOGICAL __________

APPENDIX G. TESTING ORDER

Subject	Test Order	Date
001	3	5/15/97
	2	5/17/97
	1	5/24/97
002	2	4/5/97
	3	4/16/97
	1	5/10/97
003	1	4/25/97
	3	4/29/97
	2	5/2/97
004	2	3/13/97
	1	4/11/97
	3	4/13/97
005	1	4/24/97
	2	4/26/97
	3	4/30/97

APPENDIX H. DEMOGRAPHIC QUESTIONNAIRE

DEMOGRAPHIC DATA

SUBJECT CODE:____________

PERSONAL INFORMATION

AGE:________

SEX: MALE
RACE: AFRICAN-AMERICAN

WEIGHT:__________

HEIGHT:__________

MARITAL STATUS: _____ SINGLE
_____ MARRIED
_____ DIVORCED
_____ WIDOW

EDUCATION:

____ LESS THAN HIGH SCHOOL

____ HIGH SCHOOL, BUT DID NOT FINISH

____ HIGH SCHOOL GRADUATE

____ COLLEGE, BUT DID NOT FINISH

____ COLLEGE GRADUATE

DO YOU HAVE A JOB?

______ YES ______ NO

IF YES. WHAT KIND OF JOB? DESCRIBE

MEDICAL INFORMATION

WHAT IS YOUR KIDNEY DISEASE DIAGNOSIS?

____ GLOMERULONEPHRITIS

____ PYELONEPHRITIS

____ POLYCYSTIC KIDNEY DISEASE

____ HYPERTENSIVE RENAL DISEASE

____ OTHER: ____________________

HAVE YOU EVER BEEN DIAGNOSED WITH ANY OF THE FOLLOWING DISEASES:

______ HYPERTENSION

______ DIABETES

______ ARTERIOSCLEROSIS

______ ANEMIA

______ OBESITY

______ ANY MUSCULOSKELETAL DISEASE: ________________

______ DEPRESSION

______ ANXIETY

______ STRESS

______ OTHER: ____________________________

IF YOUR ARE CURRENTLY TAKEN ANY MEDICATION, PLEASE LIST THEM IN THE SPACE PROVIDED
LIST OF MEDICATIONS:

ARE YOU PHYSICALLY ACTIVE PERSON? DESCRIBE

APPENDIX I. RAW DATA

```
data blood;
        input person trt time glu bun cre na k tp alb ldh cpk nh  ht hg ph pco po hco sao;
        list;
cards;
1 1 1 142 63 12.2 141  5.35 7.2 3.9 245 886 .0235 33.5 10.3 7.393 38.5 145 23.7 99.2;
1 1 2 131 61 12.5 141.8 5.26 7.3 4.0220 894 .0460 34.3 11.1 7.348 41.4 121 23.0 98.5;
1 1 3 114 63 12.3 143.3 5.27 7.2 4.0 230 925 .0360 33.9 11.1 7.360 40.0 120 22.8 98.5;
1 1 5 126 61 12.3 141.9 5.32 7.1 4.0 230 912 .0505 33.9 10.9 7.382 38.7 110 23.2 98.2;
1 2 1 139 32 6.9 140.8 3.97 7.6 4.0 230 645 .0420 34.9 11.6 7.440 40.4 144 27.7 99.3;
1 2 2 101 32 7.1 141.4 4.15 7.7 4.1 239 690 .0215 33.5 11.3 7.418 41.4 117 27.0 98.6;
1 2 3 88 33 7.2 142.2 4.24 7.6 4.1 245 713 .0085 32.2 11.0 7.420 41.7 114 27.3 98.5;
1 2 4 94 33 7.2 142.2 4.32 7.7 4.1 241 695 .0115 34.1 11.1 7.436 42.1 104 28.6 98.1;
1 2 5 100 33 7.2 142.1 4.36 7.5 4.0 235 682 .0130 32.1 11.0 7.436 42.3 99 28.7 97.9;
1 3 1 129 41 8.8 140.5 4.47 7.6 4.1 234 614 .0320 34.8 11.2 7.441 42.7 103 29.3 98.1;
1 3 2 106 40 8.8 141.3 4.63 7.8 4.2 250 636 .0170 35.4 11.4 7.402 45.6 93 28.6 97.2;
1 3 3 94 41 8.8 142.0 4.66 7.6 4.2 256 639 .0510 34.9 11.4 7.408 43.9 121 27.9 98.2;
1 3 4 95 41 9.0 141.7 4.61 7.6 4.2 246 639 .0095 34.0 11.1 7.421 43.7 85 28.7 96.5;
1 3 5 98 42 8.9 140.8 4.56 7.4 4.2 248 632 .0035 33.8 11.1 7.439 41.6 109 28.4 98.4;
2 1 1 95 65 16.4 139.5 4.49 6.8 3.7 179 182 .0515 39.5 12.5 7.396 41.3 117 25.6 98.5;
2 1 2 83 66 16.5 138.3 4.65 6.8 3.6 175 189 .0320 39.9 12.7 7.402 40.1 103 25.2 97.9;
2 1 3 75 66 16.6 139.7 4.67 7.0 3.7 176 194 .0360 40.7 12.8 7.415 39.7 125 25.7 98.9;
2 1 4 80 62 13.3 139.3 4.68 6.8 3.7 176 189 .0515  .  . 7.416 39.3 128 25.5 98.5;
2 1 5 88 66 17.0 136.9 4.68 7.1 3.6 170 184 .0580 39.8 12.6 7.408 37.4 112 23.8 98.5;
2 2 1 118 29 8.3 135.0 3.96 7.9 4.0 237 166 .0090  .  .  .    .    .    .  . ;
2 2 2 93 29 8.4 136.1 4.52 8.3 3.9 238 162  .   .   .  .    .    .    .  . ;
2 2 3 110 29 8.5 136.0 4.54 8.2 3.8 217 169 .0070  .  .  .    .    .    .  . ;
2 2 4 121 29 8.5 134.6 4.37 8.3 3.8 216 167 .0370  .  .  .    .    .    .  . ;
2 2 5 106 30 9.0 135.5 4.40 7.8 3.9 220 168 .0750  .  .  .    .    .    .  . ;
2 3 1 83 64 15.5 139.9 5.36 7.4 4.0 213 269 .2180 39.9 11.5 .    .    .    .  . ;
2 3 2 89 65 15.8 141.2 5.58 7.7 4.0 246 275 .1070 35.8 11.6 .    .    .    .  . ;
2 3 2 82 64 15.7 140.7 5.68 7.6 4.0 242 277 .0610 35.2 11.6 7.405 39.0 18 24.7 98.9;
2 3 5 79 66 15.9 142.1 5.57 7.4 3.8 221 267 .0980 34.8 11.2 7.400 39.3 128 24.6 98.9;
3 1 1 104 47 15.2 136.2 4.27 8.4 4.0 134 161 .5120 39.8 13.0 7.385 44.5 107 26.9 98.0;
3 1 2 77 51 15.3 138.0 4.60 8.3 4.0 136 164 .4210  .  . 7.376 42.6 109 27.4 98.2;
3 1 3 71 51 15.6 138.5 4.51 8.2 4.0 139 163 .1810 37.6 12.6 7.398 44.1 109 27.4 98.2;
```

```
3 1 4 79 51 15.4 137.5 4.56 8.2 4.0 138 165 .2800 37.1 12.5 7.383 44.6 107 26.8 98.0;
3 2 1 137 23 9.5 138.1 3.57 9.8 4.6 168 139 .2955 38.4 13.6 7.443 40.7 105 28.1 98.2;
3 2 2 95 24 10.1 138.3 4.04 9.5 4.5 157 140 .4455 39.9 13.2 7.455 39.3 96 27.9 97.8;
3 2 3 84 24 10.2 138.2 4.08 9.7 4.5 190 140 .5630 40.0 13.1 . . . . . ;
3 2 4 83 24 10.2 139.1 4.15 9.3 4.5 156 138 .3710 40.2 13.3 . . . . . ;
3 3 1 86 89 21.5 141.0 4.45 8.0 4.0 128 181 .2200 35.3 11.5 7.339 41.7 110 22.7 98.0;
3 3 2 69 89 21.4 141.3 4.72 8.2 3.9 136 186 .1585 34.1 11.5 7.363 38.4 122 22.1 98.6;
3 3 3 68 91 22.0 141.4 4.82 8.0 4.0 161 194 .1610 35.2 11.5 . . . . . ;
3 3 4 71 90 21.6 140.8 4.88 8.1 4.0 165 194 .1265 35.8 11.6 7.373 36.9 115 21.7 98.4;
4 1 1 88 73 20.6 139.7 4.95 7.7 4.0 231 743 .0780 30.7 9.7 7.338 43.9 85 23.8 95.7;
4 1 2 104 73 20.4 140.3 4.98 7.7 4.0 251 758 .1530 . . 7.337 43.5 113 23.5 98.1;
4 1 3 140 73 20.8 138.1 4.92 7.9 3.9 221 751 .2085 . . 7.348 43.2 93 24.0 96.8;
4 1 4 104 74 20.6 138.7 4.74 7.6 4.0 227 763 .3110 . . 7.358 41.2 79 23.4 95.0;
4 2 1 148 39 12.4 . . 7.4 4.0 232 883 .2175 28.8 9.6 . . . . . ;
4 2 2 107 41 12.4 . . 7.6 4.1 236 946 .1725 . . . . . . . ;
4 2 3 92 41 12.4 . . 7.5 3.9 240 983 .2155 . . . . . . . ;
4 2 4 95 42 12.5 . . 7.8 4.0 254 985 .1275 . . . . . . . ;
4 2 5 94 42 12.5 . . 7.7 4.0 243 976 .0795 . . . . . . . ;
4 3 1 106 59 15.9 139.3 4.32 7.5 3.9 202 592 .5000 . . 7.380 39.8 125 23.8 98.8;
4 3 2 99 57 15.8 139.6 4.68 7.7 3.9 196 621 .3880 . . 7.340 46.1 95 24.8 96.8;
4 3 3 93 58 15.8 140.5 4.74 7.5 3.9 208 639 .2770 . . 7.349 44.8 94 24.9 96.9;
4 3 4 88 58 16.6 141.5 4.66 7.6 3.9 225 637 .2340 . . 7.363 42.7 87 23.9 97.2;
4 3 5 82 59 16.9 141.9 4.62 7.6 3.9 207 634 .1450 . . 7.354 42.6 87 23.9 96.1;
5 1 1 117 52 15.1 142.1 4.96 7.1 4.2 203 314 .0080 34.9 11.1 7.396 38.8 110 24.1 98.3;
5 1 2 93 53 15.5 142.6 5.67 . 4.3 219 323 .0370 34.4 11.2 7.402 38.3 126 24.0 98.9;
5 1 3 110 53 15.3 141.0 5.67 . 4.2 188 322 .0510 34.2 11.1 7.407 39.7 117 25.2 98.6;
5 1 4 125 53 15.3 141.5 5.80 . 4.2 183 317 .0630 . . 7.399 39.2 117 24.5 98.6;
5 1 5 120 53 15.3 140.7 6.06 . 4.2 190 321 .0880 35.1 10.8 7.400 38.8 117 24.2 98.6;
5 2 1 114 22 8.3 139.1 4.50 8.7 5.0 245 362 .2830 37.5 12.4 7.536 34.4 132 29.4 99.3;
5 2 2 124 23 8.4 138.3 . 8.5 4.9 264 351 .3060 36.6 12.1 7.510 37.7 110 30.4 98.7;
5 2 3 123 23 8.5 139.3 4.70 8.3 4.8 230 342 .4810 36.8 12.0 7.517 36.6 120 29.9 99.0;
5 2 5 131 23 8.7 138.6 4.74 8.1 4.7 217 332 .3945 35.9 11.9 7.532 33.0 123 27.9 99.2;
5 3 1 139 49 15.0 141.2 4.94 7.2 4.2 219 857 .0505 31.9 10.5 7.454 36.6 137 25.9 99.2;
5 3 2 107 49 15.2 141.2 5.08 7.2 4.3 225 868 .0360 32.5 10.6 7.453 37.6 126 26.5 99.0;
5 3 3 121 50 15.4 140.8 4.98 7.1 4.2 190 878 .0340 32.3 10.6 7.444 37.5 138 25.9 99.2;
5 3 5 135 50 15.1 141.3 4.96 7.1 4.2 194 871 .0350 31.4 10.3 7.434 38.1 143 25.7 99.3;
run;
```

```
data crp;
        input person trt time ve vo vco r vokg kcalm;
        list;
cards:
1  1  1  39.25  1.21  .99  .82  9.575  5.872
1  1  2  13.83  .355  .27  .76  2.725  1.693
1  1  3  28.00  .766  .65  .84  6.000  3.773
1  2  1  29.63  1.11  .89  .81  11.83  5.343
1  2  2  29.73  .857  .77  .89  9.200  4.230
1  2  3  32.25  1.13  .94  .83  12.05  5.478
1  3  1  25.48  .908  .67  .74  9.700  4.320
1  3  2  11.15  .320  .25  .71  3.400  1.533
1  3  3  23.23  .842  .61  .72  9.025  3.985
2  2  1  36.95  1.46  1.2  .84  11.35  7.127
2  3  1  36.40  1.19  .97  .82  9.200  5.765
2  3  2  21.53  .637  .49  .81  4.900  3.047
2  3  3  34.70  1.53  .84  .78  8.300  5.170
3  1  1  19.73  .683  .54  .79  8.925  3.292
run;
data rpe;
        input person trt time rpe;
        list;
cards;
1 1 1 7
1 1 2 9
1 2 1 7
1 2 2 7
1 3 1 10
1 3 2 11
2 1 1 7
2 1 2 7
2 2 1 13
2 2 2 15
2 3 1 7
2 3 2 7
3 1 1 11
3 1 2 13
```

```
3 2 1 9
3 2 2 9
3 3 1 11
3 3 2 13
4 1 1 9
4 1 2 9
4 3 1 11
4 3 2 11
run;
data psych:
        input person trt time sd cra itc sob jp mw ha cpai hos anx dep posaf ss:
        list:
cards;
1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 20 8
1 1 2 0 0 0 0 0 0 0 0 0 0 0 0 21 9
1 2 1 0 0 0 0 0 0 0 0 0 0 0 0 21 8
1 2 2 0 0 0 0 0 0 0 0 0 0 0 0 21 8
1 3 1 0 0 1 0 0 1 0 0 0 0 0 0 21 7
1 3 2 0 0 0 0 0 0 0 0 0 0 0 0 21 7
2 1 1 0 0 0 0 0 0 0 0 0 0 1 0 15 7
2 1 2 0 0 0 0 0 0 0 0 0 0 0 1 14 4
2 2 1 0 0 0 0 0 0 0 0 0 0 0 1 17 7
2 2 2 0 0 0 0 0 0 0 0 0 0 0 1 15 7
2 3 1 0 0 0 0 0 0 0 0 0 0 0 0 18 6
2 3 2 0 0 0 0 0 0 0 0 0 0 0 0 9 5
3 1 1 1 0 0 1 1 0 0 0 2 3 0 15 10
3 1 2 0 0 0 0 0 0 0 0 0 1 0 16 8
3 2 1 1 1 1 1 1 0 0 0 2 0 1 13 0
3 2 2 0 0 0 0 0 0 0 0 0 0 0 0 12 8
3 3 1 1 0 0 1 0 0 0 0 0 0 0 17 2
3 3 2 1 0 0 0 0 0 0 0 0 1 0 19 4
4 1 1 1 1 1 1 1 1 1 1 0 3 0 17 5
4 1 2 1 0 0 0 0 0 0 0 0 1 0 16 6
4 2 1 1 1 0 0 1 1 0 0 0 3 1 13 5
4 2 2 0 0 0 0 0 0 1 0 0 2 3 14 7
4 3 1 0 1 0 0 0 0 0 0 0 1 0 16 6
4 3 2 0 0 0 0 0 0 0 0 0 1 0 17 8, run;
```

VITA

Marta Amaral-Melendez was born on July 8, 1964, in San Juan, Puerto Rico. She is the third born among six siblings. She attended the University of Puerto Rico. As a physical education major, she also participated in intercollegiate athletics in the disciplines of volleyball and basketball. She graduated in May, 1987 with a bachelor degree in arts. Soon after, she married Efram Melendez and began her teaching career at Bayamon Catholic High School. That year she began her volleyball coaching career, and volunteered with the Puerto Rico Track and Field Federation as a clerk of court. In January, 1993, she finished a master of science degree at Louisiana State University. A year later, she gave birth to her son Efram. She is currently finishing her doctoral studies at Louisiana State University, and will have the Degree of Doctor of Philosophy conferred in May, 1998.

DOCTORAL EXAMINATION AND DISSERTATION REPORT

Candidate: Marta Amaral-Melendez

Major Field: Kinesiology

Title of Dissertation: The Physiological and Psychological Responses to Submaximal Exercise at Different Times in Renal Disease Patients

Approved:

Major Professor and Chairman

Dean of the Graduate School

EXAMINING COMMITTEE:

Date of Examination:

August 18, 1997

IMAGE EVALUATION TEST TARGET (QA-3)

150mm

6″

APPLIED IMAGE . Inc
1653 East Main Street
Rochester, NY 14609 USA
Phone: 716/482-0300
Fax: 716/288-5989