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Characterizing Dietary Intake and Physical Activity Affecting Weight Gain in Kidney Transplant Recipients

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CHARACTERIZING DIETARY INTAKE AND PHYSICAL ACTIVITY
AFFECTING WEIGHT GAIN IN KIDNEY TRANSPLANT RECIPIENTS

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DEDICATION

This dissertation is dedicated to my husband Douglas, daughters, Virginia and Christina and to my grandson Ethan, who have supported and encouraged me with their love throughout this endeavor. It is also dedicated to my loving parents, Dorothea and Clifford, who guided me toward nursing and who have always been a source of encouragement.

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ABSTRACT

Weight gain following kidney transplant is a significant problem with 50 to 90% of kidney transplant recipients gaining weight. Potential factors leading to weight gain following kidney transplantation have been thought to include a change in lifestyle such as dietary intake and physical activity, along with the use of immunosuppressant medications to preserve the newly implanted organ. Other influences affecting weight gain include genetic determinates such as age, gender and race. There is little data to confirm which of these factors may indeed lead to weight gain and obesity. The purpose of this study was to examine dietary intake and physical activity of kidney transplant recipients at baseline, 3 and 6 months following transplantation to identify contributing factors to weight gain.

Methods: This descriptive, correlational study included secondary data to examine dietary intake, physical activity and other variables (e.g., age, race, gender and medications) associated with weight gain post kidney transplant for 44 participants, 18 years or older. Three 24 dietary intake recalls (1 weekend day and 2 weekdays) and 7 day-physical activity recalls (7D-PAR) were collected at baseline, 3 months and 6 months post transplant. Nutrition Data System for Research (NDS-R), a Windows-based dietary analysis program, versions 2007, 2008 and 2009, (developed and coordinated by the Nutrition Coordinating Center, University of Minnesota, Minneapolis, Minnesota) was used to analyze dietary data. Weights were done at baseline, 3 and 6 months. Descriptive statistics and analysis of variance (ANOVA) for repeated measures were used to compare nutrient and physical activity changes. Pearsons' product-moment correlation coefficient was used to describe the relationship of weight gain to other variables from baseline to 3 and 6 months.

Results: In the total sample, weight gain increased from 172.46 ± 34.05 to 182.09 ± 38.38 from baseline to 6 months, indicating a 6% increase in weight. Body Mass Index (BMI) increased by 5% from 26.40 ± 3.80 to 28.24 ± 4.17 from baseline to 6 months. By race and gender, African American (AA) males and females gained 11.1 and 11.7 pounds, respectively, while Caucasian males gained 9.3 pounds and Caucasian females gained 2.4 pounds. Dietary intake did not show statistical significance from baseline to 6 months. By race and gender, kilocalories ($p \leq 0.05$), total fat ($p \leq 0.035$) and total carbohydrate ($p \leq 0.048$) intake was higher in males than females. African American females had higher intake of these nutrients than Caucasian females. Hours of sleep for the total sample was reported as ($p \leq 0.02$), which showed a decrease in the number of hours from baseline to 6 months. Moderate activity ($p \leq 0.046$) showed a decrease in males and increase in females at 6 months. Hours per day of hard activity ($p \leq 0.04$) increased in Caucasian females at 6 months. No relationship was demonstrated among dietary intake, physical activity and age, race, gender and immunosuppression at 6 months.

Conclusion: Kidney transplant recipients are at risk for weight gain from a number of factors. Little consideration has been given to what kidney transplant

recipients are eating and the effects of dietary intake on weight gain. Physical activity data from this study suggest that kidney transplant recipients are not changing their physical activity levels significantly by 6 months following transplantation. Further studies using a larger group should be considered.

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LIST OF ABBREVIATIONS

AI ....adequate intake
BMI..body mass index
BUN ....blood urea nitrogen
CAD .... coronary artery disease
CKD .... chronic kidney disease
CNIs .... calcineurin inhibitors
CVD ....cardiovascular disease
DEXA .... dual energy x-ray absorptiometry
DLW .... doubly labeled water
DRI...dietary reference intake
ESRD .... end stage renal disease
FA ....fatty acids
FFQ ....food frequency questionnaire
FK560 ....tacrolimus
HIPAA ....Health Insurance Portability & Accountability Act
IL-2 ....Interleukin-2
IMPDH..inosine monophosphate dehydrogenase
KDOQI...Kidney Disease Outcome Quality Initiatives
m(TOR).. mammalian target of rapamycin
MET .... metabolic equivalent
MMF ....mycophenolate mofetil
MPA .... mycophenolic acid
NCC .... Nutrition Coordinating Center
NDS-R...Nutrition Data System for Research
NHANES .... National Health Examination Survey
NIH ....National Institute of Health
PAEE.. physical activity energy expenditure
PTDM .... post transplant diabetes mellitus
RDA ....recommended dietary allowance
SPSS/PASW ....Statistical Package for the Social Sciences,
Predictive Analytic Software 18 for Windows
TDEE ....total daily energy expenditure
TEE ....total energy expenditure
UL .... upper limits
UNOS..United Network for Organ Sharing
VO_2 ....peak oxygen consumption
WHO..World Health Organization
7D-PAR... 7Day-Physical Activity Record

CHAPTER 1. INTRODUCTION

Overview

Kidney transplantation remains the treatment of choice for many persons in end-stage renal disease. More solid organ transplants are being done throughout the world with life expectancy in some kidney recipients to exceed 40 years.[1] With post transplant obesity and cardiovascular related issues being prevalent following transplantation, the focus of transplant research should transition to factors associated with these outcomes. These factors include lifestyle behaviors associated with nutrition and physical activity.

Weight gain following kidney transplant is a significant problem with 50 to 90% of kidney transplant recipients gaining weight.[2] Findings from studies indicate a mean weight gain of 10 kg (22 pounds) in the first year after transplantation.[3-4] In earlier studies, weight gain during the first year was reported equal to or greater than 10%.[5,6]

More recently results from a large retrospective review of weight gain and body mass index (BMI) changes in the first year following kidney transplantation, Cashion and colleagues[7] revealed weight gain ranging from 6.2 kg (13.6 pounds) to 32 kg (70.4 pounds). As a result of weight gain, there has been an increase in morbidity and mortality in kidney transplant populations.[8,9-12]

Potential factors leading to weight gain following kidney transplantation have been thought to include a change in lifestyle such as dietary intake without concomitant increase in physical activity, along with the use of immunosuppressant medications to preserve the newly implanted organ. Other influences affecting weight gain include genetic determinates such as age, gender, and race[2] and psychological factors related to stress.[13] However, there is little data to confirm which of these factors may indeed lead to weight gain and obesity.

Dietary intake remains an important factor following transplantation as nutrient-related complications impact outcomes following kidney transplantation.[14] There also exists a change in the nutrient needs following kidney transplantation with different dietary recommendations for the early, later and maintenance phases post transplant.[15-17] Several dietary-related factors may contribute to weight gain following kidney transplantation including the transition from a restricted renal diet to one that is unrestricted, increased food intake resulting from feelings of well-being, and increased appetite and body fat composition from corticosteroids.[2,16]

Little is reported in the literature regarding the relationship of dietary intake to weight gain in post-kidney transplant recipients. Researchers in Mexico report significantly higher ingestion of proteins and fats than recommended dietary reference intakes (DRIs ($p \leq 0.05$) in kidney transplant recipients in eight states in Mexico. As would be expected, body mass indexes (BMIs) were higher in those transplant recipients with the higher intakes of proteins and fats compared to those with less dietary intake of

these macronutrients.[17] Other researchers recommend the importance of managing weight gain through dietary counseling and follow-up to prevent significant weight gain leading to obesity in kidney transplant recipient.[6,7] Studies by Lopez and colleagues[18] and Patel[4] have shown that dietary interventions with follow-up in the early post transplant period, can be effective in preventing excessive weight gain and that these dietary interventions may lead to weight loss.

In addition to dietary intake, physical activity levels following transplantation may influence the amount of weight gained. Post-transplant activity may be limited resulting in decreased energy expenditure leading to post-transplant weight gain.[19] In 2001, Neilens and researchers[20] reported on average, 25% less physical activity in their post-kidney transplant recipients compared to healthy subjects. Weight gain progressively increased in their participants over the five years studied.

Activity or exercise is suggested by other researchers as an intervention in the prevention of weight gain following kidney transplantation but no specific guidelines are given.[6,21] Long-term management of weight could possibly be achieved through regular physical activity following kidney transplant.[22]

Immunosuppressant medications, needed for successful allograft maintenance, may be an additional factor in weight gain following kidney transplantation. The prolonged administration of medications such as high doses of corticosteroids can lead to adverse side effects including weight gain. Immunosuppressant medications can also affect body fat distribution and the retention of excess fluid may cause weight gain in the post transplant recipient.[2,23] Significant hyperglycemia and post transplant diabetes are also common side effects of not only corticosteroids, but also seen with other immunosuppressive agents such as cyclosporine and tacrolimus.[24]

In addition, cyclosporine, tacrolimus and sirolimus, along with corticosteroids may contribute to the metabolic changes following kidney transplantation as the body is attempting to adjust from its previous state of uremia. These medications, coupled with changes in metabolic and body composition alterations put these recipients at risk for cardiovascular events.[1]

Recently, steroid free or early steroid withdrawal protocols have been employed following kidney transplantation[25] to reduce or eliminate side effects such as weight gain. However, results of several studies have demonstrated similar weight gain following kidney transplant in participants on steroid-free protocols as well as those on steroid protocols.[6,26,27]

Genetic factors including age, gender and race may be factors leading to weight gain following kidney transplantation. Several studies report a genetic predisposition related to race and gender.[4,7,28] Correlates of weight gain following kidney transplantation were found higher in African Americans than in Caucasians and higher in females and younger patients.[6]

In addition, psychological factors can also affect weight gain in these patients. Psychological factors related to stress are common among patients following kidney transplant.[13] Among the stressors are fear of organ rejection and the fact that patients must continue contending with a chronic illness.[29]

Detection of patients at risk for weight gain and obesity in the period following kidney transplantation combined with early intervention and monitoring may prevent or delay development of co-morbid disease leading to morbidity and mortality. With longer survival rates in post transplant kidney recipients, risk factor management, particularly management of cardio-vascular risk factors related to weight gain need additional study for the reduction of these and other weight-related outcomes.[2]

Problem Statement

Weight gain following kidney transplantation is a significant problem. Co-morbidities associated with weight gain in kidney transplant recipients include post transplant diabetes and cardiovascular disorders. Increased dietary intake, low levels of physical activity and the effects of immunosuppressant medications could contribute to weight gain following kidney transplantation. To tailor better dietary and physical activity interventions to transplant recipients, dietary and physical activity following kidney transplantation need to be characterized. In addition, associations among these contributing factors need to be established. By identifying contributing factors to weight gain in this population, tailored interventions can be planned and implemented to abate a significant increase in weight following kidney transplantation.

Purpose

The purpose of this study was to examine dietary intake and physical activity of kidney transplant recipients at baseline, 3 and 6 months following transplantation to identify contributing factors to weight gain. Using data from a larger longitudinal prospective study entitled "Genetics, Environment, and Weight Gain Post-transplant," the secondary data analysis answered different questions than proposed in the parent grant. Long term goal of the study was to use the identified factors associated with weight gain following kidney transplant to design individualized dietary and activity protocols that can be tailored to these recipients to avoid clinically significant weight gain in the first year following transplant. This would lead to a decrease in co-morbid conditions potentially decreasing mortality among at-risk individuals.

Specific Aims

1. Characterize micro and macronutrients in kidney recipients' dietary intake at baseline, 3 months and 6 months following transplantation.

2. Characterize physical activity at baseline, 3 months and 6 months following kidney transplantation.

3. Determine the relationship among dietary intake, physical activity, and other factors (i.e., age, gender, race, medications) to weight gain in post kidney transplant recipients.

Questions

1. Do kidney transplant recipients increase their food and calorie intake following transplantation, and if so, to what extent and at what time point?

2. Do kidney transplant recipients increase their physical activity following transplant and, if so, to what extent and at what time point?

3. What is the relationship of dietary intake, physical activity, and other factors (i.e., age, gender, race, and medications) to weight gain in post-kidney transplant recipients?

Significance of the Study

Weight gain following kidney transplantation can progress to obesity leading to poor health outcomes including coronary artery disease, hypertension, hyperlipidemia, and post-transplant diabetes.[3,30] The leading cause of death in long-term kidney transplant recipients was cardiovascular disease.[31]

There is lack of evidence as to why some kidney transplant recipients progressively gain weight. Moreover, there is little information on dietary intake of kidney transplant recipients reported in the literature. To date, few interventional trials have been conducted examining dietary intake and weight gain in the early transplant period.

Low activity levels following kidney transplantation may play a role in the development of weight gain. Individuals with end stage renal disease generally experience a sedentary lifestyle which can continue following transplantation. These recipients can experience muscle de-conditioning, exercise intolerance and fatigue.

There is currently a gap in the literature reporting macro and micronutrient intake and physical activity of post kidney transplant recipients. The issue of weight gain following kidney transplantation is a significant area of research to determine which individuals are more at risk and how unintentional weight gain can be avoided. This secondary data analysis addressed the issue of weight gain following kidney transplantation. If successful, explicated the relationship of dietary intake and physical activity to weight gain and serves as a foundation for interventional studies in this area.

Definitions of Terms

Terms will be defined as they are used in the study. Terms to be defined include nutrient, macronutrient, micronutrient, and dietary reference intakes (DRIs).Other terms defined are physical activity, immunosuppression, weight gain and body mass index (BMI).

For this study, the term nutrient is defined as constituent substances in foods necessary for chemical processes related to human tissue conservation, growth and repair. These food constituents are proteins, fats, carbohydrates, vitamins, minerals and water.[32]

Macronutrients, organic substances made up of carbon compounds, include carbohydrates, triacylglycerols (i.e., fats or lipids) and proteins or amino acids. These macronutrients serve as major energy sources for the human organism; hence, large quantities are required for cellular functioning. Excess substrates of these macronutrients, not used for energy are stored by the body for use later.[32]

Micronutrients are substances essential in small quantities for metabolic functions and growth and are not used for energy. Organic micronutrients are known as vitamins, while inorganic micronutrients are known as minerals.[32]

Dietary reference intakes (DRIs), are defined as reference values that are measurable or quantifiable for dietary intake of micro and macronutrients. DRIs also refer to the highest bounds for a nutrient intake that is deemed safe for human consumption.[33]

Weight gain is defined as added body mass when adipose tissue is stored. This can result from an imbalance in caloric intake as opposed to calories expended.[34] If energy is not spent from the caloric intake from foods, then the individual stores the excess energy in the form of fat or adipose tissue. According to Hill and Melanson,[34] genetic and environmental factors also play a role in this energy balance, or imbalance, leading to weight gain from extra stored fat.

Body mass index (BMI) is defined as a number representative of a person's height in relation to weight. It can be calculated by an individual's weight measured in kilograms, divided by the square of a person's height in meters (kg/m²). According to the World Health Organization's (WHO's) classification of BMI in 2010, underweight is a BMI of less than 18.5. Normal weight is considered for a BMI up to 24.9. BMI equal to or greater than 25 constitutes overweight status. Pre-obese classification has been added and is a BMI of 25.00-29.99, while obesity is classified as a BMI equal to or greater than 30. The WHO further delineates the classifications of obesity as: obese class I, 30.00 - 34.99; obese class II, 35.00-39.99; and obese class III, equal to or greater than 40.00.[35]

Physical activity is defined as movement in the body through skeletal muscle action producing energy usage above resting metabolic state. This movement in the body does not have to be categorized as exercise, as some activity can be divided into light activities such as slow walking and standing. Walking briskly, lifting weights and yoga are examples of physical activities that produce energy above a basal level and are considered beneficial in lowering risk of some types of health issues such as diabetes mellitus and cardiovascular related disease.[36]

When categorizing activities, the term metabolic equivalent (MET) is defined as the ratio between metabolic rate when working and metabolic rate at rest.[37] Activities can be divided into light, moderate, hard and very hard activities according to the intensity. Physical activity lasting 10 minutes or longer and of at least moderate intensity, are used to assess energy expenditure in some clinical trials.[37,38]

Immunosuppression is defined as a medical therapy used to obstruct the body's natural defense mechanisms inherent in the immune system to the newly transplanted kidney. This is achieved through the use of immunosuppressant medications to preserve the functioning of the organ and to avoid allograph rejection.[39] The balance of immunosuppression is important to prevent graph rejection as well as prevent superimposed infections, certain types of malignant tumors and to lessen or avoid side effects.[40,41] During and immediately after kidney transplantation, when acute allograph rejection is highest, the induction phase of immunosuppression is started followed by a maintenance phase.[24,41] Common immunosuppression currently used following kidney transplantation include calcineurin inhibitors (CNIs) such as cyclosporine and tacrolimus or FK560 (Prograf), mycophenolate mofetil or MMF (Cellcept), mammalian target of rapamycin (mTOR) or (sirolimus) and corticosteroids (prednisone and methylprednisolone).[41,42]

Assumptions

This study had several assumptions about the association between dietary intake, physical activity, immunosuppression and weight gain following kidney transplantation:

1. Dietary intake increases from baseline to 3 and 6 months post transplant, contributing to weight gain.

2. Low levels of activity are maintained for most transplant recipients that mirrors activity prior to transplantation and is a contributing factor to weight gain.

3. Immunosuppression is a contributing factor to weight gain following transplantation.

4. Women will, in general, gain more weight than men following kidney transplantation.

5. African-American participants will, in general, gain more weight than Caucasian participants following kidney transplantation.

Limitations

This study used 24-hour dietary intake recalls as a method of assessing micro and macronutrient intake. This type of dietary intake assessment is a self-report and relies on participant memory to recall the previous day's dietary intake. Researchers have identified that compared to healthy controls, kidney transplant recipients show increased difficulty in cognitive measures such as learning and memory.[43] These findings suggest that memory could be affected in some kidney transplant recipients, thus impacting their ability to accurately recall dietary intake. In contrast, researchers report an improvement in memory in kidney transplant recipients when compared to their cognitive functioning prior to transplantation.[44] These data suggest that improvement in cognitive functioning following kidney transplantation might be a positive factor in these transplant recipients' ability to recall dietary intake data.

Although there are limitations with this type of data collection, some strengths of the 24-hour dietary intake are built into the Nutritional Data System for Research (NDS-R), the nutrient data system used for analysis. With this nutritional data system, dietary intake data are obtained using a multisystem approach. This allows the recipient multiple chances to recall dietary intake. Opportunities to provide detailed descriptions of foods and to describe portion sizes are also a part of the system.[45] In the United States, the 24-hour dietary recall method is the type of dietary assessment most often used for collection of dietary intake.[46]

Another limiting factor in this study was the use of a 7-day activity recall, which requires participants to recall the previous 7 days' activities, including a summary of the previous 3 months' activities. This type of activity recall also relies on the memory of participants. It also does not take into account specific factors such as gender, age and body type when estimating how much energy is used in activities.[47] However, participants are encouraged to recall as accurately as possible and are reminded of the importance of data that will assist in identifying factors leading to weight gain.

There are also limitations such as participant dropout and graft loss which are inherent when conducting clinical research with kidney transplant recipients. These were controlled for in data analysis.

The inability to generalize the findings of this study to other kidney transplant populations was an additional potential limitation. Although several adjacent southern states are represented by the participants in this study, all recipients were recruited from the same urban transplant clinic. However, the sample was racially diverse, as almost equal numbers of African-American and Caucasian recipients participated in this study.

Conceptual Model

The framework that guided this study included the key variables of dietary intake and physical activity and their association to weight gain following kidney transplantation. The relationships among variables such as age, gender, race and immunosuppressant medications to weight gain following kidney transplantation were examined. The conceptual model for this study is depicted in Figure 1.1.

Justification for selecting these variables included literature searches related to previous research in post kidney transplant recipients. A gap in the literature was noted, with little nutritional data reported, although a few interventional trials have been conducted examining dietary intake, weight gain, and the impact of metabolic syndrome in the early transplant period.[1] Further justification for characterizing dietary intake was that past research targeted allograph rejection and advances in immunosuppression medication regimes in order to preserve the newly transplanted kidney. With post transplant obesity and cardiovascular related issues being prevalent following transplant, the focus of transplant research now is shifting to clinical nutrition.[1]

In all likelihood, transplant recipients return to a diet high in calories, fat and carbohydrates once they no longer have to follow a highly restricted renal diet. In addition, resolution of uremia after transplantation makes food taste better and may result in additional intake. Increased appetite and treatment with immunosuppressant medications may also be factors in weight gain following kidney transplantation.[15] Because there is a gap in the literature characterizing dietary intake following kidney transplantation to weight gain, it was a primary variable in the conceptual framework.

Physical activity following kidney transplantation may be limited, resulting in decreased energy expenditure leading to post-transplant weight gain.[19] Neilens and colleagues[20] reported 25% less physical activity in their post-kidney transplant recipients compared to healthy subjects and progressive weight gain over a 5 year period. Because few studies characterize physical activity in post-kidney transplant recipients and it has been shown to be strongly associated with weight gain across populations, it was another primary variable in the conceptual framework.

Non-modifiable factors such as age, gender, and race may predispose a transplant recipient to weight gain. Age has been shown to be a correlate of weight gain in some studies, with younger adults gaining more weight than older adults following kidney ransplantation.[6,28] Women have been shown to gain more weight than men post transplant. When comparing African American recipients to Caucasians, there is a greater weight gain at 1 year in African Americans.[3]

Immunosuppression medications have been implicated in previous studies as having a significant association with weight gain.[48] However, early withdrawal of steroids is employed to limit weight gain following kidney transplantation.[9,23,49] Elster and researchers[26] found that kidney transplant recipients gained weight regardless of the immunosuppressant protocol.
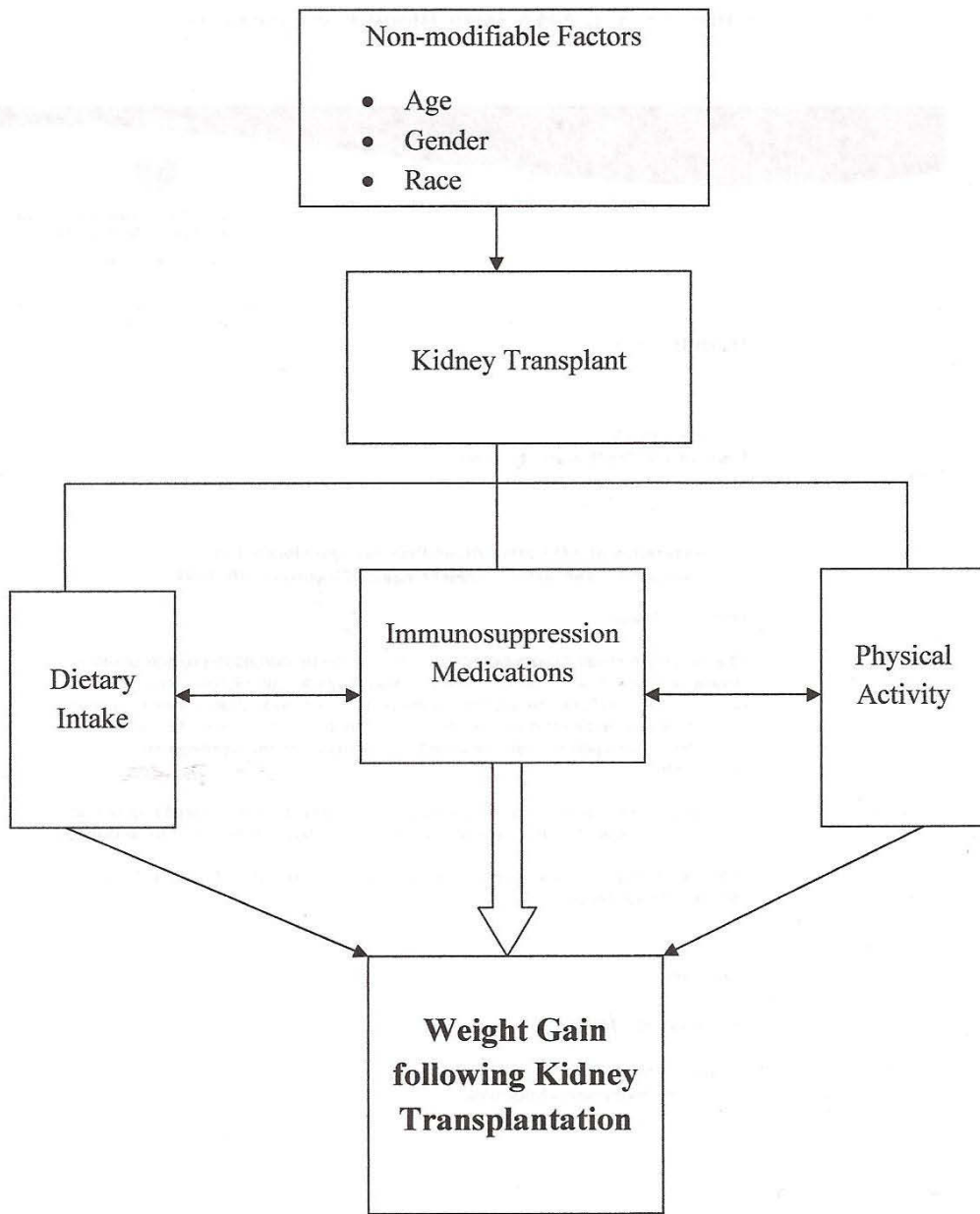
Figure 1.1 Post Transplant Weight Gain Model

In the current study, most recipients were on four types of immunosuppression medications, tacrolimus, mycophenolate mofetil, and sirolimus, along with prednisone. Because there will be little variation, it was not expected to be a major factor in weight gain following kidney transplantation.

Findings from this study contribute to existing knowledge about post-transplant weight gain in kidney transplant recipients by identifying associations between various nutrient intakes, levels of physical activity and medications post transplant as depicted in the framework. Knowledge of significant weight gain at specific time points would assist in guiding interventions and patient teaching regarding how to prevent weight gain. Pre and post-transplant interventions regarding the types of nutrient intake, physical activity and medications that contribute to weight gain could be devised in a collaborative effort among nurses, physicians and dietitians. Detailed plans could be tailored to persons awaiting transplant according to age, gender and race to prepare them for positive outcomes post transplant. These data could be the basis for further interventional studies with post-transplant recipients.

Summary of the Chapter

Following the problem statement, this chapter included a discussion of (a) purpose, along with specific aims and questions, (b) significance, (c) definitions of terms, (d) assumptions, (e) limitations, and (f) conceptual model of the study. The effects of dietary intake, physical activity, and medications used for immunosuppression are important factors that could lead to post transplant weight gain. As in the general population, weight gain can lead to co-morbidities such as obesity, diabetes mellitus, and cardiovascular issues; for post kidney transplant recipients; these co-morbidities can occur with weight gain as well. The intent of this study was to determine the association between dietary intake, activity, age, race, gender, and immunosuppression and weight gain post kidney transplant.

CHAPTER 2. REVIEW OF LITERATURE

This chapter presents pertinent literature related to the concepts in this study. The first section provides research-based information related to weight gain in the general population and in kidney transplant recipients. The second section addresses dietary intake in kidney transplant recipients. The third section contains research-based information on physical activity in post kidney transplant recipients. The next section integrates transplant immunosuppressant medications and nutrient interaction. The final section summarizes this chapter.

Weight Gain

Weight Gain in the General Population

Nationally, the prevalence of overweight and obese adults has been trending upward in the United States over the past 40 years.[50] In the most recent data related to obesity in the National Health Examination Survey (NHANES), a sample of 8,082 adults aged 20 and over, from both genders, showed 34.2% of adults in the United States were overweight in 2007-2008, and 33.8% were obese. More men (72.3%) were overweight or obese than women (64.1%).[51]

Globally, WHO estimates that 1.6 billion adults are overweight, while obese adults number 400 million.[51] Global increases predicted in the year 2015 could reach about 2.3 billion overweight adults, while obese adults will be greater than 700 million.[51] By the year 2020, if the trend in overweight and obese adults continues, it is predicted that nearly half of the adults in the US will be obese, according to the World Health Organization's (WHO) criteria for obesity.[52] Excess adipose tissue places individuals at risk for the development of type 2 diabetes mellitus, hypertension, ischemic heart disease, hyperlipidemia and other chronic diseases.[51]

Body mass index (BMI) is commonly used to categorize weight in individuals using both the person's height and weight for a more accurate representation of a person's body fat than just using weight itself. Researchers have shown that BMI is a correlate of other methods measuring amount of body fat, such as dual energy x-ray absorptiometry (DEXA) and measurement of weight underwater.[53] BMI, used to assess groups for classification of overweight and obese categories, is inexpensive to use and allows individuals to compare their weight category to others. However, BMI is higher in some groups and would not necessarily mean that an individual has excess fat tissue. For example, athletes who have more muscle mass might be in a higher BMI category, even though they do not have excess fat tissue.[54]

Health Outcomes of Weight Gain in Healthy Adults

The impact of weight gain in healthy adults has serious health consequences, with increasing morbidity and mortality.[55] Weight gain leading to excess body weight is well documented to be a prime risk factor for disorders of the cardiovascular system such as coronary artery disease (CAD), hypertension and hyperlipidemia.[55,51] Additional disorders linked to excess body weight are type 2 diabetes, some cancers and disorders of the musculoskeletal system.[51] Not only does weight gain increase the prevalence of the previously mentioned disorders, it can also cause exacerbations, or worsening, of existing chronic disease in these individuals leading to more negative outcomes.[55]

Weight Gain in the Post Kidney Transplant Recipient

Weight gain and obesity have been noted in post kidney transplant recipients.[3-5,7] In a retrospective review of 974 kidney transplant recipients between July 1993 and April 1998, weight changes were analyzed. At 1 year following transplantation, the mean weight gain was 10.3 kg (22.6 lbs.), with a range of 75 to -23 kg or median of 10 kg (22 lbs.). Greater weight changes were seen in blacks (117.3%) compared to whites (113.2%), $p \leq 0.0004$. Women gained more than men (118.4% and 112.1%, respectively), $p \leq 0.0001$. Age showed an inverse correlation with weight gain ($p \leq 0.0002$).[3]

Another retrospective review of 506 kidney transplant recipients between 1983 and 1999, reported at one year following kidney transplantation, African-Americans had gained significantly more weight (13.6 kg) than whites (9.1 kg) and others (9.5 kg). This increase in weight was also shown at 2 and 3 years following kidney transplantation with mean weight gains for African Americans of 16.2 kg and 16.4 kg compared to Caucasians, 11.5 kg and 11.1 kg at years 2 and 3, and 11.5 and 11.6 kg in others at years 2 and 3, respectively.[48]

In a prospective study of 50 kidney transplant recipients, researchers found that mean weight gain for all participants was 4 kg (8.8 lbs), $p \leq 0.0001$, for the first 6 months following kidney transplantation. It was also noted that 30% (4 females, 11 males) of the participants did not gain or lose weight during the first 6 months. More incidents of post transplant complications, (i.e., allograft rejection and infection) occurred in the group that did not gain weight or lose weight. Contributing factors in the group that did not gain or lose weight could have been related to stress, catabolism, continued uremic state, delayed sense of well-being and altered dietary intake related to hospitalizations and treatment for rejection and infection. Females gained more than males (8 kg verses 7 kg, respectively). Researchers concluded that early dietary intervention for female recipients might be warranted, but further studies are needed to design weight control protocols.[5]

In a more recent prospective study, Cashion and colleagues[7] found that there was an increase in mean weight (6.2 ± 10.7 kg) during the first year following kidney transplantation. Of the 171 individuals in the study, 70% were overweight or obese at the time of transplant. This was compared to a group of individuals reported in the list obtained from the United Network for Organ Sharing (UNOS) that indicated that 60% of

those in the national database were overweight or obese at the time of transplant. This indicates that not only is weight gain important to note following surgery but also many of these transplant recipients are overweight or obese at the time of transplant. More weight gain has been documented in patients who are moderately obese at the time of transplant than in non-obese patients.[3,56]

El-Agroudy and research team[23] documented that weight gain occurred in the first 6 months following transplant and that weight gain tended to increase after that but at a slower rate. They speculated that this weight gain could be attributed to nutritional intake, lessened rates of activity and a higher amount of steroids in their pharmacological protocol.

A literature review done by Pischon and Sharma[57] of nine studies in 2001, indicated that significant weight gain in patients categorized as non-obese and obese was seen in individuals after kidney transplantation. Weight gain in non-obese transplant recipients was reported as 9 kg, as compared to obese individuals who gained 14 kg in the year following transplantation.[58] Still another study reviewed by Pischon and Sharma's[57] reported weight gain of 8.5% in both non-obese and obese recipients 1 year following transplantation.[59] Similarly a 10.9% weight increase at 1 year post transplantation increased to 15.3% over a 5-year period.[6]

These studies support that weight gain occurs in post kidney transplant recipients regardless of the pre-transplant weight status. Weight gain is more pronounced during the first year following transplantation.

Dietary Intervention Studies in Post Kidney Transplant Recipients

Some studies have tested dietary interventions in post kidney transplant recipients to investigate weight gain and outcomes following transplantation. To determine the effect of a dietary intervention on weight gain following kidney transplantations, Patel and colleagues included 32 study participants in 2 groups. The intervention group (Group A) was given individualized dietary advice for the first 4 months following transplantation. This group, consisting of 11 participants (9 males, 2 females), was followed prospectively for 1 year. In contrast, the second group (Group B) was not given any dietary guidance or follow-up. Mean weight for Group A was 67kg ± 13 kg at baseline, 69kg ± 12 kg at 4 months and 73 kg ± 12 kg at 12 months compared to Group B, mean weight 67kg ± 11 kg at baseline, 74kg ± 9 kg at 4 month and 79kg ± 12 kg at 12 months. Both groups gained weight; however, mean weight gain of 5.5 kg per recipients was seen in the intervention group compared to a mean weight gain of 11.8 kg per recipient in Group B. Researchers concluded that dietary intervention during the early post transplant period, along with follow-up, could be a factor in limiting the amount of weight gained during the first 12 months following kidney transplantation.[4]

In another nutritional intervention study involving 23 (16 females) kidney transplant recipients, researchers in Spain reported mean weight loss was 3.2 kg ± 2.9 kg after 6 months. Initial body weight (kg) was 77kg ± 13kg, with final body weight of 74

kg ± 12kg (p < 0.001) for the total group. The dietary intervention used in this study was the *American Heart Association Step One* pattern. Along with improvement in body weight, there was an improvement in total cholesterol (237 mg/dL to 224 mg/dL; p < 0.05) in males, along with a reduction of low-density lipoprotein cholesterol of 136 mg/dL from 156 mg/dL, p < 0.05. Low-density lipoprotein values were not affected in females following the nutritional intervention. Researchers concluded that obesity, as well as hyperlipidemia could be reduced after dietary intervention.[60]

Improvement in body mass index (BMI) and metabolic syndrome were found during the first year post kidney transplant by Bellinghieri and colleagues[61] in 2009, using a diet low in fat and calories. While tapering steroids, these investigators found that with the dietary intervention, BMI could be reduced.

In 2007, Guida and colleagues,[56] documented improvement in nutrition, body fat and weight during the first year following kidney transplant by prescribing a low fat and low calorie diet during their trial. In addition, improvements were seen in cholesterol levels, fasting serum glucose and albumin. Data from a study by Guida and his research team[56] suggest that referrals made to dieticians early in the post transplant period, helped to prevent weight gain. They found that by doing repeated dietary assessments on their patients, they observed better compliance in their patients resulting in energy balance and an improvement in their nutritional status. Consistent weight loss was demonstrated by their patients, especially in males who followed a diet lower in protein, cholesterol and sodium.

Health Outcomes Related to Weight Gain in Kidney Transplant Recipients

It is recognized that weight gain following kidney transplant poses undesirable health outcomes, such as a higher incidence of cardiovascular disease (CAD), including hypertension and hyperlipidemia, post transplant diabetes mellitus (PTDM) and obesity.[1,2,62] The leading cause of death in kidney transplant recipients is CAD.[1] However, there are conflicting results in studies reviewing the effects of obesity on outcomes following kidney transplantation.[63]

A retrospective review of 427 kidney transplant recipients between 1987 and 1992 reported that 50 of their participants developed atherosclerotic CAD in the post-transplant follow-up period, which was 28.6 ± 20.2 months. Coronary artery disease occurred more frequently (9.8%), in their participants. Other cardiovascular-related incidents were peripheral vascular disease (2.7%) and cerebrovascular disease (1.6%). Forty-six percent of these 50 participants exhibited CAD prior to transplantation. Out of the 427 recipients studied, 34 deaths occurred after transplantation of which 32.4% were attributed to cardiovascular complications and 35.3% were related to infection—still making deaths from infection as the main cause of mortality in this study.[64]

In a prospective study of 506 kidney transplant recipients between 1983 and 1998, the most common cause of death (40%) was related to CAD. African Americans had the highest frequency of death from cardiovascular disease (n = 20), followed by Caucasians

(n = 7) and other (n = 5). Post-transplant diabetes (PTDM) had developed in 66 recipients (32%) during the first year following kidney transplantation. Nonwhite participants (African Americans and others) were two times more likely to develop PTDM than whites.[48]

Dietary Intake in Kidney Transplant Recipients

Overview of Biochemical Processes in the Kidney Related to Nutrition

Biochemical processes in the kidney are complex and relate to nutrition by regulating vitamin D, calcium and phosphorus, electrolyte balance (sodium, chloride, potassium) and maintaining acid-base balance. Gluconeogenesis, amino acid metabolism, fatty acid metabolism and maintaining water balance in the body are other biochemical processes in the kidney.[65]

Prior to receiving a kidney transplant, individuals undergo hemodialysis, usually for a number of years, as a treatment for end state renal disease (ESRD). Due to the nonfunctioning kidneys, these biochemical processes in the kidneys are altered. Thus, health care providers must consider the nutritional needs of persons in end-stage renal disease and in the period following kidney transplantation.

Calcium homeostasis is an important biochemical process performed by the kidneys related to the production of the active form of vitamin D, 1-25-dihydroxy vitamin D or calcitrol. This active form of vitamin D facilitates the absorption of calcium and phosphorus in the intestines. The kidney's response to calcitonin and parathyroid hormone is important in maintaining calcium balance.[65,66]

Calcium ions are necessary for all cells of the body and are important in the bone mineral composition. Calcium ions are filtered in the glomerulus and are reabsorbed by the renal tubules. This movement of calcium is accomplished through calcium channels or by passive movement. Sodium/calcium exchangers, or Calcium adenosine triphosphatase (calcium ATPase), is responsible for this ionic movement in the distal tubules.[65]

Calcium binds with a protein, calbindin, within the cytoplasm. In order to activate, calbindin requires 1, 24-dihydroxy vitamin D. The formation of 1, 24-dihydroxy vitamin D is stimulated by parathyroid hormone, PTH, which also promotes excretion of phosphate in the urine.[65]

Another important biochemical process in the kidney related to nutrition is the active transport of potassium and sodium into and outside the cell. The enzyme sodium/potassium adenosine triphosphatase (sodium/ potassium-ATPase), present in the ascending loop of Henle and the proximal tubules has a role in this process. Through active transport system which depends on ATP for energy, sodium chloride is reabsorbed from the tubules into the peritubular space. D-glucose and amino acids are transported

into the blood along with sodium. With leakage of potassium into the lumen, more sodium is caused to move into the cell. Potassium is lost via both an active and a passive system, thus potassium is always excreted regardless of the amount consumed. Sodium, on the other hand can be decreased if little is consumed. Chloride ions are actively transported along with the sodium ions.[67]

Involved in maintaining acid-base balance, hydrogen ions are secreted into the urine via the proximal portion of the renal tubules by sodium/hydrogen exchangers and hydrogen-ATPaseses. Hydrogen ions are used as substrates for the sodium/hydrogen exchangers in the ascending loop of Henle, and excess hydrogen is excreted. Ammonia is secreted by the α- intercalated cells forming ammonium. Bicarbonate is secreted by the β-intercalated cells and reabsorbed in the tubules to maintain acid-base balance. Gluconeogenesis occurs in the renal cortex but does not supply a significant amount of glucose to the body. Fasting states increase gluconeogenesis, as does hormones of epinephrine and glucagon by cAMP. During fasting states, fatty acids and ketone bodies are the energy sources for gluconeogenesis, and phosphoenolpyruvate carboxykinase is the enzyme. Acidotic states cause increase in messenger RNA, which increases the production of this enzyme.[68] Amino acid are catabolized through deamination, which results in cleaving off an amino acid group from the molecule, resulting in ammonia and keto acid. The kidney uses glutamine that is hydrolyzed to ammonium ion and glutamate, which then gets oxidized to α-ketoglutarate. This process of ammonia production begins with an enzyme, phosphate-dependent glutaminase, located within the matrix of the mitochondria. During acidosis, ammonia is formed by increased activity of glutaminase glutamate and by an increased transport of glutamine into the mitochondria.[67] A small amount of ammonia is excreted by the kidneys, with the remainder incorporated into urea. Uric acid is formed by the degradation of purines, whereas the resultant nitrogen from degradation of pyrimidine is excreted as urea in the urine.[69]

Creatine phosphate, found in muscle, is changed to creatine and excreted by the kidneys. Since creatine is not reabsorbed by the renal tubules, it is used as a measure of kidney function.[69]

Finally, maintaining water balance in the body is achieved through the kidney's ability to stabilize fluid volume and regulate osmolarity of body fluids. The kidneys have the ability to remove excess substances and water and to conserve deficit substance and water.

One of the mechanisms to explain fluid balance is in reference to plasma osmolarity. The ratio of NaCl to total body water is affected by excess or decreased amounts of water. Physiological feedback mechanisms assist in stabilizing plasma osmolarity. Feedback mechanisms for blood volume and blood pressure changes also affect thirst and excretion of water through the kidneys.[70]

Circulating arginine vasopressin (AVP), a small peptide made up of amino acids, is responsible for regulating the concentration of the urine, whereas, aquaporins, or transport proteins, primarily AQP-2, are responsible for transporting water in the tubular

epithelium. The binding of AVP to receptors activate adenylate cyclase which increases cyclic AMP to activate AQP-2 to move the water. The opposite functions occur when AVP is removed and AQP-2 water channels are reincorporated back into the cell, so the membrane is no longer permeable to water.[70]

Dietary Recommendations for Pre-transplantation Period

It is important in the pre-transplantation period to manage recommended dietary intake in individuals with chronic kidney disease (CKD) to maintain muscle mass, create a positive nitrogen balance and to prevent increased fat mass. The effects of CKD and hemodialysis impact the nutritional state of individuals awaiting kidney transplant. An increasing issue in these individuals is the number of overweight or obese persons awaiting transplantation, as 60% of obese transplant recipients were reported between 1987 and 2001.[71] These individuals in the pre-transplant period should be monitored by health care providers to maintain optimal nutritional status and to prevent some nutrient related complications post transplant such as overweight or obesity.

According to the National Kidney Foundation's Kidney Disease Outcome Quality Initiatives (KDOQI),[72] recommendations for daily energy intake in individuals with end stage renal disease (ESRD) is similar to recommendations in healthy adults. Based on metabolic studies of persons being treated for ESRD by maintenance hemodialysis, KDOQI[72] recommends 35 kcal/kg/d for those below 60 years of age and 30 to 35 kcal/kg/d for those older than 60, according to their level of physical activity, to maintain neutral nitrogen balance.

Protein intake for persons in ESRD has been a controversial issue in the literature. As noted in the KDOQI guidelines, these persons can be malnourished due to a number of causes, including poor nutrient intake related to decreased appetite, depression and acidemia. Issues with amino acid removal with the dialysate as well as the hypercatabolic nature of the illness or dialysis may also contribute to poor nutritional status. Daily protein intake is currently recommended at 1.2 g/kg weight/d. This amount for protein intake would likely produce neutral or positive nitrogen balance for most persons who are clinically stable.[73] Traditionally, protein intake has been restricted to 0.6-0.8 g/kg/day, but now, may be reserved for those persons not on dialysis, to slow the progression of the disease.[74]

The percent fat intake would be tailored to the individual related to cardiovascular risk factors but is generally recommended to be 20-30% of the energy intake.[74] If high risk for CVD is present, then the recommendations are less than 10% saturated fat and 250-300mg cholesterol per day.[66] Percent carbohydrate should make up the remainder of the nonprotein calories[75]

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Dietary Recommendations following Kidney Transplantation

The management of dietary intake recommendations for kidney transplant recipients with functioning allografts impact outcomes related to morbidity and mortality.[25] Dietary recommendations for the renal transplant recipient in the early post-tranplant period is recognized by Blue[76] as 4–6 weeks following surgery and defined by Wilkinson[77] as the first 3 months post-transplant. With functioning allograft, kilocalorie requirements are specified as 30–35 kcal/kg body weight/day and protein 1.3–2.0g/kg/body weight/day.[16,25] Meeting adequate needs for energy and protein to prevent post operative complications of infection, decreased wound healing and loss of muscle mass is a goal of nutritional intervention. These recommendations would also promote calcium and phosphorus balance to minimize bone loss in these recipients.[15] Percent calories from fat are recommended at 30–35%,[16] and percent calories from carbohydrates at 50%.[16,76]

In this early transplant period, normal kidney functioning is supported and continues to be established and maintained. During this time, kidney transplant recipients have certain dietary recommendations to support their hemodynamic and electrolyte balance. Mineral recommendations for these individuals include sodium intake of 3000–4000 mg per day if unrestricted. However, if hypertension, edema, fluid retention and absence of urine output are issues, sodium intake is restricted.[16] In the presence of hypertension related to calcineurin inhibitors sodium would be restricted to 2000 mg daily.[25] In contrast, 80 to 100 mmol/day (1440mg–1800 mg) of sodium intake is recommended in the 2009 Australian Evidence-Based Guidelines for the Nutritional Management of Adult Kidney Transplant Recipients to manage hypertension.[14] Sodium intake recommendation of 1300–2300 mg is recommended for the general population in the absence of hypertension.[66]

Potassium intake of 4700 mg daily is recommended in post kidney transplant recipients,[76] as in the general population[66] and would be restricted to 1000–3000 mg in hyperkalemia, hypercalcemia and/or oliguria.[16] As with sodium, serum potassium can be elevated with the use of CNIs and thus would necessitate potassium restriction.[77]

Calcium recommendation is 1000–1500 mg/day with supplementation as necessary[76] which is similar to recommended adequate intake of 1000 mg per day. A recommendation of 1200–1500 mg daily of phosphorus is noted[16] and is higher than the adequate intake amount of 700 mg recommended for the general population.[66] Hypophosphatemia is an issue in the early post transplant period due to phosphaturia[16] and is seen in about a fourth of recipients with proper allograft functioning, sometimes requiring supplementation of dietary phosphorus. Magnesium recommendations are 200–300 mg daily[15] may need to be supplemented in the diet.[76] This is lower than the recommended daily intake of magnesium for males (400–420 mg) and females (310–320 mg) in the general population.[66]

For the prevention of long-term complications associated with post-transplant recipients such as excessive weight gain leading to obesity, hyperglycemia, hypertension, hyperlidemia, hypercholesterolemia and osteoporosis, goals of care would target these

co-morbid conditions. To tailor caloric needs to the individual to attain or maintain desirable weight, calories would need to be adjusted. Protein recommendations would be 0.8 to 1.0 g protein/kg body weight, based on serum albumin levels and assessment of patient status. Carbohydrate intake of simple sugars is discouraged to maintain blood glucose and avoid weight gain. Dietary fiber of 25–30 g/day is encouraged to assist in the maintenance of blood glucose and cholesterol levels and in the prevention of excessive weight gain. Limiting fat intake to 30% or less with 10% or less saturated fat, 10% polyunsaturated fat and the rest from monounsaturated fats in accordance to the American Heart Association (AHA) guidelines for Americans would help with maintaining cardiovascular health while also limiting cholesterol intake to 300 mg daily.[76]

Fluid and electrolytes, as well as vitamins and minerals should be tailored to the individual as previously discussed in the early transplant period. Restriction or supplementation would depend upon monitoring serum levels of these nutrients on a regular basis post-transplant.

Macro Nutrient Intake Post Kidney Transplant

Very few research studies report the micro-and macro nutrient intake following kidney transplantation. A cross-sectional study by Pulgar and colleagues[17] reported the macronutrient intake in 119 (56% males) kidney transplant recipients from eight states of Mexico attending the Mexico National Olympiad. Macronutrient consumption obtained through 24-hour dietary recall was analyzed for nutrient composition using the e-dossier nutrition program.

In Mexican states that border the United States of America (USA), BMIs were higher (≥ 25 kg/m^2) among those transplant recipients compared to BMIs in states in Mexico that do not border the USA. Significantly higher ingestion of proteins and lipids than recommended DRIs ($p < 0.05$) was also demonstrated in these border line states in Mexico than in other states in Mexico. Of the states showing higher intake of proteins and lipids, the state of Nuevo Leon had the highest intake of percent fats (30.22 ± 0.8) as compared to recommended 25.6 ± 0.7. Researchers suggested that these results could be a reflection of the industrialized nature of the states bordering the USA and mirroring the USA's dietary intake practices.[17]

In a prospective study during the first year following kidney transplantation, Haggan and colleagues investigated outcomes of nutritional markers and body fat composition in 44 post kidney transplant recipients. A dietary protocol of 30 to 35 kcal/kg/d and 1.3 to 1.5 g/kg/d of protein recommended during the first 3 months following transplantation. Fat intake was suggested at < 30%, cholesterol intake was restricted to < 300 mg/d and simple sugars were restricted from dietary intake. Participants completed a 3-d food record, recording all foods consumed.[78] All participants in the study,[78] had a mean energy intake of 29.6 kcal ± 7.5 and a protein intake of 1.1 g ± 0.4. The dietary intake of energy and protein steadily increased to the 6 month time point (32.6 kcl ± 7.2 and 1.36 g ± 0.33) and stabilized at 1 year (31.7 kcal ±

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6.4 and 1.33 g ± 0.31). Weight loss and a decrease in fat mass were seen by these researchers in male recipients, suggesting that nutrition/dietary recommendations could have a positive influence on weight gain post transplant.[78]

Dietary Reference Intakes (DRIs)

The term Recommended Dietary Allowance (RDA) is the former label used for standards of gauging nutritional sufficiency since 1941. The current term, DRI, was introduced in 1997 replacing RDA in the United States.[79] Developed by the National Academy of Sciences' Institute of Medicine (IOM) of the United States Agricultural Department (USDA), along with the government of Canada, DRIs also replace Recommended Nutrient Intakes (RNIs), formerly used by Canada.[79]

DRIs, the current method of depicting reference standards related to identified nutrients, include the previously used term RDA, along with the three other distinct reference values. The four reference values included in the new DRIs are the estimated average requirements (EAR), recommended dietary allowance (RDA), adequate intake (AI) and tolerable upper intake level (UL). These four values can be used when planning interventions for individuals and groups, as well as assessing dietary intake of these entities. The advantage of having four reference values, as opposed to one reference value (i.e., RDA), is that varied types of reference values can be applicable to recommended nutrient intake for either individuals or groups.[79]

Most nutrients have EAR which have been established, as well as a corresponding RDA, related to the EAR. If there is no established EAR, a related RDA has been identified. In the case of no DRI (and thus no RDA), an AI has been determined. Other nutrients have UL which have been established as the tolerable upper limit for that nutrient to be acceptable.[79]

All of the DRIs represent an average of the daily nutrient intakes, similar to the previously used RDAs and RNIs. This new set of four distinct DRIs now represents a distribution of nutrient requirements as opposed to a single number.[80]

The first of these reference values is the Estimated Average Requirement (EAR). This takes into account the daily projected nutrient intake quantity required by 50% of healthy individuals accounting for gender and life stage.[79] The second reference value, RDA is developed from the EAR and is the dietary nutrient level needed on a daily basis to fulfill the nutritional needs of almost all healthy persons (i.e., 97-98%), in order to prevent or decrease the development of chronic disease. The RDA accounts for variation in nutrient requirements within certain groups (i.e., males, females, children, persons over 70 years and lactating females). The third reference value is the Adequate Intake (AI). This quantity is used when an RDA for a particular nutrient has not been determined through research. It is used to establish goals for individuals to prevent chronic disease, for example, to decrease fat intake for adults or to sustain a component of desired health such as retention of calcium in bones.[79] Finally, the Upper Limits (UL) reflects the upper or highest level of average intake for a nutrient that will not create undo risk of

unfavorable health issues in healthy individuals in the population. Intake levels exceeding the UL could pose health risks.[79]

24-hour Dietary Recall

Several methods for collecting dietary intake data include food frequency questionnaires (FFQ), diet histories, food record method and the 24-hour dietary recall. The method used depends on the type of data needed. Advantages of 24-hour dietary recall and the food record methods are that actual amounts of food and fluid consumed by participants are reflected. Twenty-four hour dietary intakes and food records are considered more accurate methods of assessing dietary intake as opposed to the FFQ and diet histories.[81]

This current study used the 24-hour dietary recall method, the most widely employed method of obtaining dietary intake data in the United States. This method has been used by the National Center for Health Statistics for collection of dietary data for the three National Health and Nutrition Examination Surveys (NHANES): NHANES I (1971-1975), NHANES II (1976-1980) and NHANES III (1988-1994) and for NHANES Hispanic subgroups.[81,82] In addition, the 24-hour recall method has been used by the U.S. Department of Agriculture Surveys and in clinical trials with nutritional components.[81]

There are other advantages of the 24-hour dietary recall as opposed to other methods of collecting dietary intake data. Historically, the 24-hour dietary intake method has been done in a face to face interview format with participants. More recently, telephone interviews have become a common method of collecting dietary intake. The two advantages of telephone interviews are apparent. The first advantage is that the telephone precludes the need for the participant and interviewer to meet at a designated location. This is especially useful when multiple days of dietary intake are obtained, as in this study. The second advantage is that the interview can be done on a day that is unexpected or unannounced to the participant, in the hope that their eating habits will not be altered by the anticipated recall.[81]

Although there are advantages in telephone interviews when collecting 24-hour dietary intake, there are some disadvantages. One disadvantage of collecting dietary intake using telephone interview is the lack of ability to show pictures of food or to use food models for participants to estimate food portion size. Other disadvantages to this method are similar to those of face-to-face interviews including inaccurate reporting of foods eaten and inability of participants to remember food intake from the previous day. The interview situation could also lend itself to a potential bias in the responses of the participants.[83]

The collection of dietary intake data using the 24-hour dietary recall method is subject to a degree of error.[84] However, the error of data collection using the 24-hour dietary recall method can be reduced. The main source of error in data collection is the participant's memory. Skillful interviewers using prompting and probing questions related to the participant's preceding 24-hour dietary intake can assist participant's recall

of consumed food and fluid in the preceding 24-hour period. This can be accomplished in part, by relating food intake to activities done during the previous day. A list of commonly forgotten items such as candy, cookies, chips and drinks can also assist participants to more accurately recall intake.[81,85]

Underreporting, another source of error of 24-hour recall of dietary intake, can occur but may be reduced if participants are thoroughly briefed on the process of the 24-hour dietary recall method. The use of a multiple-pass system allowing the interviewer to use a hierarchical system while gathering more detail with each pass lessens underreporting when gathering dietary intake data.[81] Multiple-passes also allow the interviewer to obtain more detailed descriptions of foods, lessening inadequate description of foods as another source of possible error.[85]

The day- to-day variation in dietary intake in participants is a source of random error, which is a part of dietary intake measurements. The multiple-pass approach, along with multiple days, help to lessen this degree of error when gathering dietary intake data.[85]

Another key aspect of gathering accurate dietary intake is the interviewer's emphasis on the importance of the participant's assistance to the research. It is necessary for the interviewer to stress the value of their contribution to the research study.[81]

Another source of error for the 24-hour dietary recall method is the estimation of portion sizes by participants. This type of error can be reduced by the use of standardized household measures such as teaspoons, tablespoons and cups and by estimating portion sizes in three dimensions using inches.[81]

Finally, the motivation of the participants to accurately describe details necessary for a thorough 24-hour dietary recall can be a source of error. The establishment of rapport in a professional, nonthreatening manner, where participants feel free to respond, can be a motivating factor for participants to more accurately respond to the interviewer. Incentives to participants, such as money and the knowledge that they are contributing to research, might also increase motivation.[81]

Reliability and Validity of 24-hour Dietary Recalls

A study conducted to assess the accuracy and precision of four different types of dietary intake collection were compared in a small cohort of healthy young women (n = 20) and older women (n = 20). Food intake data was collected using 24-hour recalls, 7-day weighed food intake data and food frequency questionnaires (FFQs) and 2 previously validated FFQs. These four food consumption records were compared with total energy expenditure (TEE) using doubly labeled water. The participants drank the doubly labeled water and collected urine specimen for 8 days.

Results showed that of the four methods used, 24-hour recall method was more congruent with TEE in younger women and that one of the FFQs, Willett FFQ, was

closest for energy intake to TEE in older women. In this study, the more complex method of 7-day weight dietary intake was no more precise than the other less complex methods. Researchers concluded that although these dietary intake methods are considered suitable for measuring energy intake, that further studies need to be done to determine accuracy of these dietary intake assessment methods.[86]

Another study evaluating 24-hour recalls as compared to four-day food records, reported that unannounced 24-hour recalls were the preferred method of collecting dietary intake data as opposed to the 4-day food record. Although underreporting can be present in all types of dietary intake data, these researchers suggest that through the use of skilled interviewers asking probing questions, underreporting can be decreased. Their data showed a relatively low level (8%) of underreporting which they attribute to the manner in which their trained interviewers conducted the dietary recalls.[87]

A more recent study in Brazil using healthy women (n = 65) between the ages of 18 and 57 years comparing FFQ, food records and 24-hour recalls using doubling labeled water, showed similar results. Less underreporting of energy intake was seen using the 24-hour dietary recalls and food records as compared to FFQ method.[88]

Nutrition Data System for Research (NDS-R)

The NDS-R was developed by the Nutrition Coordinating Center (NCC) at the University of Minnesota in Minneapolis in 1974.[89,90] In collaboration with the National Heart, Lung and Blood Institute (NHLBI), the data system software was developed and used for two research programs at its inception. This led to the establishment of the Nutrition Coordinating Center (NCC) by the National Institute of Health (NIH), which continues to be a renowned national center for research at the University of Minnesota.[89,90] Since then, the system has continued to change and grow into a comprehensive research database used by hundreds of institutions in the United States as a research instrument.[90]

The NDS-R is maintained by the NCC at the University of Minnesota and is updated on a regular basis in order to reflect current foods consumed in the United States. Ethnic foods as well as specific age group populations are included in the comprehensive database.[89,90]

The comprehensiveness of this food and nutrient database is demonstrated by the number of foods and food brands in the system. Currently, the NDS-R contains over 18,000 foods and 7,000 brands of food products. Prepared foods with ingredient choices number more than 160,000 foods.[91]

A major part of the database is the nutrients contained in food. The nutrient list currently contains 160 nutrients. Ratios of nutrients and other components related to food such as energy sources, fat and cholesterol, carbohydrates, fiber, vitamins and minerals are included. Other food components more recently added are carotenoids. Sugar alcohol, amino acids, isofavones and other food components are a part of the system.[91]

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Another important feature of the database is the assignment of foods to food groups, including fruits, vegetables, grains, dairy and alternatives, meats and meat alternatives, fats, sweets, beverages and miscellaneous foods. These food group assignments are further delineated into 166 subgroups.[91]

Still another feature that makes this database attractive to researchers includes the standardization of the system using published imputation. For example, to have a complete nutrient database, it is sometimes necessary to impute or calculate values from similar foods as in ingredients in frozen dinners and the nutrients in each ingredient. This can be done in a variety of ways including using values from a similar food or a different form of the food, using calculations from recipes or nutrition labels, to name a few.[92]

Finally, updates to the system are made annually and released to licensed users. These updates reflect many changes in the current food market. Analytic data is also improved with each annual update.[93]

Specific studies when using NDS-R can design study specific protocols when there is a questionable food or amount to enter into their data. These data entry rules are established and recorded by the research team and made available to those collecting and entering data. This information lends itself to more valid and reliable data entry since consistency among team members are established.[93]

To meet the need for stability of nutrient database, several versions of the Food Table remain available. Even with updates, the users for long term studies will have the nutrient values determined for foods when the consumed foods were reported. At the end of the study, investigators can determine to use the original nutrient content or the updated versions as necessary.[94]

In order to evaluate validity and reliability, quality control measures to verify data entry of various food sources, need to be part of a data system.[92] Suggestions for quality control include reviewing the system's manual, editing any improperly entered data, or data in error. Other quality control measures include consistency of the program among the nutrient values of foods that are similar and consistency of nutrient contents within foods. These are automatic in NDS-R. Data consistency is also maintained by comparing nutrient values to algorithms of expected food values.[92] If discrepancies are found between the calculated algorithms, and what is contained in the database, nutrient ranges are flagged and investigated by NCC personnel.

Another demonstrated means of maintaining validity and reliability includes the standardized method of interviewing prompts that are included to guide the dietary recall interview on various screens in the software. This method uses the feature of direct data entry using an interactive process.[95]

Another measure to ensure validity and reliability is NDS-R's multiple-pass method of obtaining the participant's recall. This gives the researcher four occasions to gather information for accuracy and completeness as previously discussed.[95]

Still another means of validity and reliability is demonstrated by the number of reviews of the data. The first review is with the participant, second is when the investigator reviews the data following the interview and thirdly by confirming amounts on any data entry errors.[95] Standardization of food portions using household measures such as cups and teaspoons/tablespoons increase validity and reliability of the data received and entered.

To further discuss validity and reliability, it is imperative that users of NDS-R have documentation regarding how nutrients are calculated and the sources of information used for this dietary data. The coding system in NDS-R designates the reference source including the page number or a specific code from the source. Examples of sources for nutrient data include the United States Department of Agriculture (USDA) reference, scientific journals, food tables and other sources in which nutrient data can be obtained. Researchers can determine the reliability of the nutrient data by the sources of the data used in the food tables provided.[94]

In an ongoing attempt to maintain accuracy of the data base to maintain reliability of data, NDS-R developers employ several methods of quality control to achieve this. These include updating NCC Food Table on daily basis allowing for modifications in nutrients. Another way includes periodic checks of accuracy for the "Reference Food Table" by reviewing the algorithms used for calculations of nutrients for any deviations. Finally tests can be done to check various calculations and compare to previously calculated test records for nutrient values.[94]

Finally, inter-study comparability is also possible with NDS-R, which allows investigators to compare nutritional data between studies done in the past and in the future. Even foods that are no longer available on the market are maintained in the database. Recalculated values as updates occur can be compared to older versions of the food product.

In order to evaluate validity and reliability, quality control measures to verify data entry of various food sources, need to be part of a data system.[92] Reviewing the system's manual, editing any improperly entered data, or data in error, consistency of the program among the nutrient values of foods that are similar and consistency of nutrient contents within foods are automatic quality control features in NDS-R. Data consistency is also maintained by comparing nutrient values to algorithms of expected food values.[92] If discrepancies are found between the calculated algorithms, and what is contained in the database, nutrient ranges are flagged and investigated by NCC personnel. Still another means of validity and reliability is demonstrated by the number of reviews of the data. The first review is with the participant, second is when the investigator reviews the data following the interview and thirdly by confirming amounts on any data entry errors.[95]

Standardization of food portion visuals, graphic paper and food amounts booklet using measurements also increase validity and reliability of the data received and entered.

Reliability and validity of the NDSR has been well established. Since its inception in the 1970's, the database has been used in many clinical investigations for analysis of dietary intake. Its use has been identified in trials related to cancer, cardiovascular disease and hypertension, and in gastrointestinal and bone health disorders.[89]

Physical Activity in Kidney Transplant Recipients

Along with nutritional management, physical activity and conditioning play a role in the prevention of secondary complications (i.e., obesity) following kidney transplantation. Kidney transplant recipients generally show an improved capacity for activity and exercise as compared to their pre-transplant level.[25]

Health Benefits in Kidney Transplant Recipients

Physical activity on a regular basis following kidney transplant is important for several reasons. The possibility of minimizing weight gain while lowering risks of co-morbidities such as cardiovascular disease and diabetes is of primary importance.[77] Improvement in quality of life and feelings of well being are also desirable.[96]

However, conditions developing prior to transplantation, such as fatigue and muscle de-conditioning leading to weakness, are obstacles for physical activity. Poor motivation for physical activity many also be a barrier.[96,97]

Following kidney transplantation, cardiac output may be reduced due to a number of reasons such as cardiomyopathies, which could limit some types of activities such as aerobic exercise.[96] Blood pressure is also affected in kidney transplant recipients due to denervation of the transplanted kidney, so blood pressure could be higher in these individuals following exercise.[98]

To illustrate these cardiovascular issues, researchers employing a prospective research design tested exercise capacity in 16 kidney transplant recipients for 2 years following transplantation. Peak oxygen consumption (VO_2 max) was significantly lower in the transplant recipient group compared to the healthy control group at 1, 4 and 10 months but not at 16, 24 and 48 months. VO_2 max did not show improvement in these participants after 16 months. The reason for this decrease in VO_2 max was thought to be the adverse correlation of VO_2 max with resting systolic blood pressure prior to exercise ($r = -0.26$, $p \leq 0.039$), suggesting a lack of normotensive parameters in the sample. Echocardiographic structural changes and VO_2 max were negatively correlated with diastolic diameter of interventricular septum ($r = -0.37$, $p \leq 0.004$) and systolic diameter interventricular septum ($r = -0.38$, $p \leq 0.003$). Negative correlations were also seen in left ventricular end-systolic volume ($r = -0.49$, $p \leq 0.043$) and VO_2 max. These researchers conclude that exercise capacity of post kidney transplant recipients is lower than healthy

controls and suggest future studies of a larger prospective nature to see if permanent improvement of cardiovascular issues and exercise capacity can be achieved with these transplant recipients.[99]

In another prospective study designed to follow 32 kidney transplant recipients for 5 years, researchers administered two validated questionnaires through interviews, the Baeche and the Five City Project 7-day recall to post kidney transplant recipients. These participants were interviewed about their pre-transplant physical activity about 15 days after transplantation. They were also interviewed using the two instruments at 1, 3, 6 and 12 months following transplantation. Due to participant loss to follow-up, only 18 participants were available to interview at the 5-year time point.[20]

These researchers found that compared to healthy controls, the transplant recipients were significantly less active and scored between 18% and 35% lower at the pre-transplant interview. However, physical activity showed a significant increase within the first year in these transplant recipients and showed ~ 30% mean physical activity level increase which was significantly different from pre-transplant physical activity levels.[20]

7 Day-Physical Activity Record (7D-PAR)

This study used the 7 Day-Physical Activity Report (7D-PAR) to assess physical activity at baseline and at three and six months following kidney transplantation. The 7D-PAR is an instrument for gathering self-reported physical activity recall from participants through the use of interview, either face to face or per telephone. Moderate, hard or very hard exercise performed continuously for at least ten minutes is recorded. Time spent in light activities and sleep is recorded for the previous seven days.[100]

When classifying activities by their required energy, the term of metabolic equivalent (MET) is used. This method of describing energy expenditure takes into account the ratio of working to resting metabolic rate. Activities are classified and assigned a number according to their MET as follows: sleep – 1 MET; light activity – 1.0–2.9; moderate activity – 3.0–5.0; hard activity – 5.1–6.9 and very hard activity – >7.0.[100]

Some difficulties have been identified with use of the 7D-PAR. First, interviewers need to be trained in the use of the 7D-PAR to gather data and to classify the METs for activities. Second, the time required per interview is approximately twenty minutes and may discourage its use with some researchers. Last, as with any self-reported data, the participant's ability to recall the previous seven days of activity, along with ambiguity of certain activities, may be an issue. However, use of the 7D-PAR with populations can characterize their activity levels, requires an acceptable amount of time to gather data and is appropriate for use in studies to gain knowledge about a particular study group.[100]

Various studies have examined the validity of the 7D-PAR. Test-retest reliability using 64 participants showed a Pearson correlation of r = 0.83, (p < 0.0001) between

amount of reported vigorous activities. More variability was seen in Pearson's correlation in moderate activity (r = 0.75, p < 0.0001). Reliability coefficients varied for other components but these researchers reported stable means during the 2 week testing interval. Reported factors possibly attributing to these variations in reliability coefficients were gender and being overweight. Reliability of reporting energy expenditure was higher in males than females, demonstrated by Pearson's correlation.[100]

Criterion validity, along with reporting error factors, was examined in a moderately overweight group of young adult, both male and female, using doubly labeled water (DLW) with healthy controls. Two measures from the 7D-PAR, total daily energy expenditure (TDEE) and physical activity energy expenditure (PAEE), were compared to the healthy controls of young adults using doubly labeled water. The 7D-PAR and DLW were used to calculate PAEE. Significant differences in TDEE were not found between the 7D-PAR and DLW. No significant difference was found in mean PAEE from 7D-PAR and DLW. These data show that mean TDEE and PAEE were reliable estimates for group means but may not be reliable for calculation of individual PAEE.[101]

Another means of evaluating reliability and validity of self reported data from the 7D-PAR was compared with data from triaxial accelerometer (RT_3) during July 2002 and August 2004 in a random clinical trial. One hundred thirty-nine recent breast and prostate cancer survivors participated in a diet and exercise intervention. Moderate agreement between the 7D-PAR and accelerometer was demonstrated at baseline (r = 0.54), 1 year (r = 0.24) and 2 years (r = 0.53) with all p values < 0.01. For moderate-to-vigorous physical activity, estimates were higher with the accelerometer. These data show modest agreement between self-reported physical activity and accelerometer.[38]

Compendium of Physical Activities

The Compendium of Physical Activities originally developed by Ainsworth and colleagues[47] in 1993 is a coding method for physical activities. Self- reported physical activity data surveys, as well as physical activity logs and records, can be coded for use in observational studies. A five digit code represents certain physical activities of different intensities using metabolic equivalent intensity level (MET). Resting metabolic rate when an individual is sitting quietly is representative of one MET. The Compendium contains lists of activities that are multiples of this resting MET state. For example, sleeping is represented by 0.9 while running at 10.9 miles per hour is designated by 18 METs. The updated Compendium includes a supplementary list of activities representing suggested additions from researchers over the past ten years. Various other types of daily activities and their MET values have been added to the Compendium to represent interests of public health research.[37]

Value and Limitations of Using the Compendium

When using the Compendium for research, it is important for investigators to record only the time the participant spends in actual movement when energy costs or

METs are measured. The original intent of the Compendium was not to measure absolute energy requirements of certain activities, but instead, proposes a means of classifying physical activities in a standardized manner so that MET intensities could be estimated.[37]

A limiting factor to the Compendium is that factors such as age, gender, body types and body fat compositions are not considered. Other factors such as environment and ease of bodily movements are not accounted for in individual differences when calculating MET levels. Some activities contained in the Compendium are not based on indirect calorimetry. Similar activities may have similar MET values giving altered confidence levels around mean MET values for those activities.[37]

Immunosuppression following Kidney Transplantation

Adequate immunosuppression is crucial to maintaining the new transplanted kidney. The balance is a delicate one, preventing rejection of the allograft while avoiding the effects of over-suppression leading to infections, cancers and side effects, such as nephrotoxicity, that could threaten the transplanted kidney.[102] Along with preserving the newly implanted kidney, another goal is to decrease the long-term side effects of immunosuppressant medications. The benefits, compared to the risks of chronic steroid administration, are being questioned, causing a paradigm shift to steroid taper regimens or steroid free protocols used in some practices.[103]

Immunosuppressant medications currently used in clinical settings are described as using a T-cell activation and proliferation model. This model is made up of three signals causing T cells to activate. During the first signal, T-cell receptors are triggered by antigen-producing cells (APCs) causing a specific antigen signal which leads to the antigen being transduced through the CD_3 complex.[41]

The second signal results in secretion of interleukin-2 (IL-2) and other cytokines. This is caused by the interaction of B_7 on the APC and CD_{28} on T cells. Activation of mammalian target of rapamycin (mTOR) is achieved through stimulation of the IL-2 receptor (CD_{25}). This second process causes the third signal to initiate leading to cellular proliferation.[41]

Immunosuppression is represented by two distinct phases known as induction and maintenance. At the time of transplantation, or during induction, monoclonal or polyclonal antibiotics are used targeting specific processes in the immune system. The maintenance phase continues during the recipient's life and usually consists of a combination of medications including corticosteroids, calcineurin inhibitor (CNI) and antiproliferative agent.[24]

Dietary Aspects of Immunosuppressant Medications Affecting Weight

Although the use of immunosuppressant medication is vital to the preservation of the new implanted kidney, these medications have side effects. One of the possible side effects of corticosteroids and immunosuppressant medications is weight gain.

Corticosteroids or glucocorticoids, directly affect carbohydrate metabolism. Blood glucose concentration in the blood is caused by gluconeogenesis in the liver. At the same time, blood glucose is increased, uptake of glucose into other cells such as muscle, adipose and lymphatics is decreased. This decrease use of glucose peripherally and an increase blood glucose causes insulin to be secreted. These glucocorticoids also increase appetite and promote fat deposits in the face and neck area.[104]

Corticosteroids have been used for over 40 years in immunosuppressive regimens. However, some centers are now tapering steroids in the early transplant period while others are employing steroid free protocols.

Corticosteroids used over long periods of time have side effects that are well documented. Side effects such as weight gain, hypertension, hyperglycemia, and post-transplant diabetes, along with increased blood lipid levels, impact cardiac co-morbidities following kidney transplantation. Muscle wasting affects could also impact physical activity following kidney transplant.[24]

Several classifications of immunosuppressant medications are currently used in clinical practice. These include corticosteroids, calcineurin inhibitors (CNIs), mTOR inhibitors and antiproliferative agents.

The CNIs prevent the synthesis of interleukin (IL)-2. Common to the kidney transplant recipients in this study is tacrolimus, a CNI which binds to proteins inside the cells of cyclophilin (FK-binding protein). This intracellular binding process leads to inhibition of IL-2 mediated T cell activation and prevents proliferation of lymphocytes.[24] Posphatase activity is inhibited by the resultant drug-protein complex leading to diminished IL-2 synthesis.[105]

Because tacrolimus (Prograf) is metabolized by the cytochrome P450 enzyme system in the liver, the possibility of drug and food interactions can occur. For example, grapefruit or grapefruit juice are known to reduce or inhibit the P450 system, thus changing levels of CNIs metabolized by the same metabolic pathway in the liver.[24]

Tacrolimus has other side effects such as posttransplant diabetes, hypertension, hypomagnesemia and hyperkalemia. Magnesium supplements and low potassium diet are used to treat these electrolyte imbalances following kidney transplantation.[24]

The mTOR inhibitor, sirolimus, has a different mechanism of action than the CNIs. The binding of sirolimus to calcineurin at the FK binding protein then binds mTOR interfering with cell replication at the G1 to S phase. Metabolism of sirolimus also

occurs in the cytochrome P450 system, making drug-food interactions as stated earlier with CNIs a potential issue.[24]

Side effects of sirolimus having dietary implications include alterations in triglycerides and cholesterol. Diarrhea and other gastrointestinal disturbances can also impact dietary intake and absorption of nutrients from dietary intake. Modification of diet, use of antilipid medications and omega-3 fatty acids (fish oil) have been useful in the treatment of lipid abnormalities associated with the use of sirolimus.[106]

Finally, the last classification of immunosuppressant medications prescribed to participants in this study are the antiproliferative agents, namely MMF (Cellcept). The active compound in MMF is mycophenolic acid (MPA) which inhibits an enzyme, inosine monophosphate dehydrogenase (IMPDH). IMPDH affects the denova synthesis of purine affecting production of quanosine nucleotides from quinine. This action in turn has antiproliferative effects on lymphocytes which rely on denova synthesis of proteins. It has no effect on cytokine production, unlike calcineurin inhibitors and sirolimus.[107]

Side effects of MMF that would impact nutrition are nausea and diarrhea. Recipients on MMF experiencing gastrointestinal symptoms could have poor dietary intake resulting in decreased kilocalories and weight loss. These side effects can be lessened by reduced dosage and shortened intervals between doses.[24]

The potential dietary interactions of these medications require monitoring following kidney transplantation. Dietary issues present prior to transplant should be addressed. Follow-up after kidney transplantation should address potential issues such as weight gain and other side effects mentioned that could affect dietary intake in the months following transplantation.

CNIs Affecting Weight Gain following Kidney Transplantation

A retrospective study of 99 kidney transplant recipients between 1988 and 2006 assessed the effects of two types of calcineurin inhibitors on weight gain following kidney transplantation. The first group of recipients received cyclosporine A (CyA), while the second group was prescribed tacrolimus (Tac). Both groups received prednisolone in addition to either Cya or Tac, and either mycophenolate mofetil (MMF), azathioprine or interleukin-2 receptor antagonists. Prednisolone was progressively reduced at the first, second and sixth months. Weight gain was statistically significantly increased ($p < 0.01$) after six months. Twelve month weight gain was 3.8 kg ± 6.8 kg in the Tac group and 8.7 kg ± 7.8 kg in the CyA group. Although both groups gained weight, more weight was gained by the group using CyA which suggests that the type of immunosuppression could affect the amount of weight gained following kidney transplant.[108]

Summary of the Chapter

In summary, weight gain is an issue in the general population and in kidney transplant recipients following transplantation. Evidence-based information is documented regarding the health outcomes in the general population and some research done in post kidney transplant recipients report similar co-morbidities related to weight gain. A body of knowledge is lacking in the dietary intake practices of individuals following kidney transplantation. Weight gain is pronounced in the first year following kidney transplantation with a slower trajectory of weight gain after the first year following transplantation. Studies suggest that increased calorie intake without concomitant increase in physical activity lead to weight gain in these individuals. Even though some physical activity investigations have been done, intervention studies designed along with prescriptive dietary interventions could impact the amount of weight gain in these individuals. As per the findings in some of the studies in the review, immunosuppressant medications may also play a role in weight gain following kidney transplantation, but the evidence is not clear as to which medications affect weight gain in individuals post transplantation.

CHAPTER 3. METHODOLOGY

Research indicates that weight gain leading to obesity following kidney transplantation is a significant problem. Relationships between weight gain and co-morbid diseases have been established. Factors including increased dietary intake, low physical activity and immunosuppressant medications have been suggested as the cause of weight gain. However, there is little data documenting dietary intake and physical activity of kidney transplant recipients. Thus, this study set out to characterize micro and macronutrient intake and physical activity in persons following kidney transplantation. In addition, this study determined if associations exist between dietary intake, physical activity, immunosuppressant medications and weight gain following kidney transplantation. This chapter describes the methodology of this study including research design, setting, sample, and procedures.

Research Design

A descriptive, correlational study included secondary data to examine dietary intake, physical activity, and other factors (e.g., age, gender, race, and immunosuppressant medications) associated with weight gain following kidney transplantation. All participants were enrolled in a larger 5-year, prospective longitudinal study examining genetics (expression profiles), environmental factors (e.g., dietary intake and physical activity) associated with weight gain leading to obesity following kidney transplantation. Dietary intake and activity recalls were done via face to face interviews in the university hospital's kidney transplant clinic or by telephone interview at baseline, three and six months. Clinical data were obtained through the university hospital's electronic records or by charts located in the transplant clinic.

Sample

This secondary data analysis provided examination of dietary intake, physical activity and other variables (e.g., age, gender, race, immunosuppressant medications) associated with weight gain post kidney transplant. After obtaining institutional review board approval, dietary intake, physical activity and clinical data were used from participants enrolled in a larger, 5 year longitudinal study exploring environmental and genetics factors and their association to weight gain and obesity after kidney transplantation. The participants in the parent transplant obesity study were transplanted between August 2007 and August 2009 at a large Midsouth university-hospital-based transplant institute. The inclusion criteria for the parent study included 18 years of age or older, must be able to read and understand English. Exclusion criteria for the parent study included receiving steroid therapy prior to the time of transplantation.

Forty-eight participants who had reached their 6 month time point and had baseline, 3 and 6 month dietary, physical activity and weight data were considered for the secondary data analysis. Participants were excluded if they lost greater than 10% body

weight from baseline to 6 months. Blackburn and colleagues[109] identified weight loss greater than 10% in a 6 month period as significant. This percent weight change usually accompanies poor oral intake or medical illnesses[110] and indicates a state of protein malnourishment, impacting immune functioning, morbidity and mortality.[109] This study looked at dietary intake, physical activity and age, gender, race, and immunosuppressant medications and their association to weight gain, thus excluding the four participants who had lost greater than 10% body weight in the first 6 months following kidney transplantation.

Four participants (1 African American male, 1 African American female, 1 Caucasian male, 1 Caucasian female) were excluded because they had lost more than 10% of their baseline body weight at 6 months. Thus, 44 participants (22 males and 22 females) who had signed informed consent for the parent study and had reached their 6 month time point since transplantation were included in this secondary data analysis.

To minimize a threat to confidentiality, participant identification numbers were used. All data was password protected in a computer database. Consent forms were kept in a separate locked cabinet. Participant confidentiality was in compliance with the Health Insurance Portability and Accountability Act (HIPAA) guidelines for electronic data. Participants in the parent study had been informed about data collection, usage and storage to conform to HIPAA regulations. No other potential risks were identified.

Setting and Recruitment

A large teaching hospital located in the south eastern United States was the recruitment site for the larger parent study. Participants were recruited by core team members of the parent study either in the kidney transplant clinic or at various renal dialysis clinics. Consent forms were signed by the participants after a thorough explanation by core team members. Following approval by the university's Institutional Review Board the principle investigator of the parent study provided deidentified data and the secondary data analysis was conducted.

Procedures

For this study, dietary and physical activity data from baseline, 3 and 6 months post-transplant time points were used. Participants in the larger longitudinal prospective study had been informed of the various time points (baseline, 3 and 6 months) that dietary intake and activity recalls would be obtained. Most of the recall data were done per phone during regularly scheduled appointments in the transplant clinic. Twenty-four hour dietary intake was obtained at baseline and at 3 and 6 months following transplantation to include one weekend day and two weekdays of food and fluid. Seven-day activity recall interviews were done at baseline and again at 3 and 6 months post-transplant. BMI was calculated on all participants at their pre-operative workup visit to the clinic. Weight was measured at baseline and at the 3 month checkup and at the 6 month checkup using the

medical scales in the transplant clinic. Age, gender, race and immunosuppressant medications and other clinical data were obtained in the larger prospective longitudinal study by reviewing chart information in the clinic or by reviewing the electronic medical record.

Dietary intake, physical activity data and clinical data were downloaded from the two databases where data had been entered for the larger longitudinal study. Dietary data from output files generated by NDSR were downloaded into a Microsoft Excel spreadsheet before exporting into Statistical Package for the Social Sciences, Predictive Analytic Software 18 for Windows™ (SPSS/PASW) version 18.0 (SPSS, Inc., Chicago, IL). Each nutrient variable of interest was maintained in the Excel spreadsheet. The physical activity data and clinical data were downloaded into a Microsoft Excel spreadsheet. Dietary intake, physical activity and clinical data were then merged into one single file for analysis of the variables of interest.

Managing the data in the study, including data cleaning and preparation were necessary steps before data analysis could take place.[111] Data cleaning of the dietary data involved inspecting each nutrient value for outliers in comparison to a reference DRI value. If extreme values for participants were found, verification of the data was made by reviewing the original data from the handwritten 24-hour dietary recall. After that, subsequent review of the data entry into NDS-R was performed to check for any data entry errors. If one or two days of the three days of dietary intake was present at a time point instead of all three days, means were imputed using the available data or a mean of the nutrient for the group was used for a missing value.[112]

Physical activity data were downloaded from the storage database for the larger longitudinal study into an Excel spreadsheet before importing into SPSS for analysis. Cleaning the data involved inspecting for outliers and other irregularities. Any questionable data such as excessive amounts of physical activity were verified by first checking the original 7 D-PAR interview document where data were recorded and comparing it to data entered into the database for analysis.

When creating the secondary analysis files, the names of the variables and the coding decisions were entered into an electronic codebook. Each variable was carefully named to ensure easy recognition of corresponding data in the spreadsheets when imported into SPSS.

Once all of the data was in one spreadsheet, a second data cleaning was done to ensure that all measurements and time points were congruently entered into the original data. Because of data entry errors, weight entered into pounds was calculated into kilograms. In addition, errors in time point coding were corrected.

Instruments

In this study, empirical data were obtained using the following approaches: (a) three day 24 hour dietary intakes entered into the Nutritional Data System for Research (NDS-R), (b) 7 Day-Physical Activity Record (7D-PAR) and (c) clinical data from transplant recipient chart reviews of electronic kidney transplant clinic records.

Dietary Intake

3 Day 24-Hour Dietary Recalls

Dietary intake records consisted of 3 weekday recalls and 1 weekend recall. Participants were informed that each diet recall would take about 20-30 minutes in the larger longitudinal prospective study. The participants were contacted by phone regarding the dietary recall or interviewed face to face in the transplant clinic while awaiting a scheduled appointment. These unannounced dietary recalls were obtained using a multi-pass prompted script interview. Participants were given three chances to give as much detail about the diet intake as possible. Diet data was verified by the investigator before it was entered into the computer. Data was analyzed by the NDS-R for Windows software into nutrient components including micro and macronutrient values.

The 24-hour dietary recall method employs an interview situation with trained research personnel to gather explicit information about a participant's food and fluid intake for the previous 24-hour period. Probing questions are used to gather sufficient detail about the consumed dietary intake starting with the first time of the day that the participant had anything to eat or drink and progressing forward. The accuracy of the 24-hour recalls is dependent upon the skill of the interviewer, as well as the memory of the participant about the previous 24-hour period.[81]

Validity of the 24-hour dietary recall method has been established through the use of this method in dietary surveys in the United States. Twenty-four hour recalls have been used to gather dietary diet in multiple government initiatives such as by the National Center for Health Statistics and the National Health and Nutrition Examination Surveys, as well as numerous large research studies.[81] If describing the mean intake of a group is the purpose of the study, then a single 24-hour dietary recall is the appropriate method. Multiple days of dietary recall are considered by some experts to give more dietary information and is considered to be the gold standard when assessing the dietary intake of individuals. The one day, 24-hour recall can yield valuable data when obtained through prompting and clarification by the interviewer.[113]

Several strengths are associated with the 24-hour recall method. Because this method is based on actual reported intake, estimated intakes of kilocalories, and micro- and macronutrient absolute values rather than relative values can be determined. Specificity of information is enhanced through the use of detailed descriptions of foods reported by the participants using a structured interview process. Details regarding foods

(e.g., sources, preparation method and amounts) can be obtained to answer research questions.

Another major strength of the 24-hour dietary recall method is that literacy issues are not a hindrance to the use of 24-hour dietary recall. Participants are not required to read or complete any written material.

The validity of this method is strengthened since it is generally an unannounced or unexpected event which lessens the chances of participants altering their dietary intake patterns.[87] With 24-hour dietary intake recalls taking 20 to 30 minutes on average, participant burden is also decreased.[81]

Limitations of the 24-hour dietary recall method have been identified. A major limitation is that this method does rely on participant memory to call the previous 24-hour food and fluid intake. Generally with this method, foods are not weighted or measured. The approach relies on the participants' estimation of sizes and descriptions.[81] Limitations are discussed further in the limitations section in Chapter 4.

NDS-R

The use of computer software for data entry related to nutrition and dietary recall and its analysis of nutrients and other food components have aided nutrition research. The Nutrition Data System for Research (NDS-R), developed by the Nutrition Coordinating Center (NCC) at the University of Minnesota, is a Windows-based dietary analysis program used for entry and analysis of dietary intake. Considered the "gold standard" for dietary analysis, it contains data for 160 nutrients and food constituents, and is updated yearly to reflect changes in nutrient composition of foods and food market changes.[90]

Features of NDS-R include the comprehensiveness of this food and nutrient database and the current nutrient list. These features are demonstrated by the number of foods and food brands exceeding 18,000 foods and 8,000 brands of food products. Prepared foods with ingredient choices number more than 160,000 foods.[91] The nutrient list currently contains 160 nutrients. Ratios of nutrients and other components related to food such as energy sources, fat and cholesterol, carbohydrates, fiber, vitamins and minerals are included. Other food components more recently added are carotenoids. Sugar alcohol, amino acids, isofavones and other food components are a part of the system.[91]

Reliability and validity has been established for NDS-R as a research database. It is a research tool extensively used by hundreds of institutions collecting and analyzing dietary intake.[114] It has been used in a variety of clinical trials to calculate dietary intake data for various dietary-related diseases.[89] When comparing four nutrient databases (e.g., ESHA Food Processor, NDS-R, Moore's Extended Nutrient Database, and Nutritionist IV databases) with their chemical component data from a hypertension focus trial, the four nutrient databases, intraclass correlation between the sites of data entry was 0.998. Although some variance was noted among the four nutrient databases, it was small (<

10%) for some nutrients. Measures of bias and precision showed significant differences in some nutrients (e.g., kilocalories, saturated fatty acids, and polyunsaturated acids); their corresponding laboratory values had a variance of < 15% with the exception of iron. Accuracy and precision for the nutrients in this hypertension research study, performed well in all of the four databases.[115]

To maintain validity and reliability of NDS-R, quality control measures to verify data entry of various food sources, are a part of the data system.[92] Quality control is maintained by reviewing the system's manual, and editing any improperly entered data, or data in error. Other quality control measures include consistency of the program among the nutrient values of foods that are similar and consistency of nutrient contents within foods. These are automatic in NDS-R. Data consistency is also maintained by comparing nutrient values to algorithms of expected food values.[92] If discrepancies are found between the calculated algorithms, and database entries, nutrient ranges are flagged and investigated by NCC personnel. Other means of maintaining validity and reliability include standardization of interviewing prompts, multiple-pass approach used during interviewing, number of reviews of data, coding system for reference sources for nutrient data and inter-study comparability.[116]

Physical Activity

Assessment of participant activity was accomplished using the 7 Day-Physical Activity Recall (7D-PAR) interview. It has been widely used since the early 1980s as a general measure of physical activity, either work related or non-work related, in a variety of studies. Participants recall activity, sleep patterns and physical activity behaviors over the preceding seven days during a structured face-to-face or phone interview. In addition to sleep, classification of activity include moderate, heavy and strenuous based on the instrument's measurement criteria. Participants provide examples of activities and the amount of time for each activity that fit the designated categories. Metabolic equivalent (MET) value is assigned by the interviewer to various levels of activity based on the updated Compendium of Physical Activity. A MET value is calculated as the ratio of metabolic rate during work to the resting metabolic rate of 1.0 (4.18 kJ) $kg^{-1} \cdot h^{-1}$. Multiples of the resting MET level are used to assign values to activities with a range of 0.9 (sleeping) to 18 METs (running at 10.9 mph).[37] The METs are then used to estimate kilocalorie expenditure.

Test-retest reliability (r = 0.77, p ≤ 0.0001) was reported by Sallis and his team,[117] in a cohort of children and adolescents, while comparing interviewers completing a five session group training program, Gross and colleagues reported a test reliability of r = 0.99 in healthy individuals while testing the skills of interviewers.[118] Convergent validity (r = 0.70, 0.66, p ≤ 0.05) examination was done comparing 7D-PAR with activity logs of men ages 34-60 years.[119]

Still another study comparing validation of the 7D-PAR telephone interview version to 7D-PAR face-to-face interviews using the same protocol, reported intraclass correlation between the two methods for total minutes of activity for the total days as r =

0.96, r = 0.94 for moderate, r = 0.97 for hard, and r = 0.97 for very hard activities. In comparing the TriTrac-R3D accelerometer to the 7D-PAR phone interview, Pearson product correlation for the total physical activity for the 7 days were r = 0.43, r = 0.31 (moderate activity), r = 0.39 (hard activity), and r = 0.78 (very hard activity). Pearson Product correlation coefficients for the week comparing the face to face 7D-PAR and TriTrac-R3D was r = 0.41, r = 0.33 (moderate activity), r = 0.43 (hard activity) and r = 0.74 (very hard activity). These data show that the 7D-PAR phone interview and the 7D-PAR face to face methods were similar for obtaining self-reported activity from adult participants. The results were also comparable to validated activity measured by the TriTrac-R3D.[120]

Criterion validity of the 7D-PAR was evaluated in a group of young adult males and females in the moderately overweight category using doubly labeled water (DLW). The parameters assessed by the DLW were compared to total daily energy expenditure (TDEE) and the physical activity energy expenditure (PAEE). The comparison of activity expenditure measured by the DTW and the 7D-PAR showed no significant difference in both males and females. Thus, the 7D-PAR is a practical means to estimate TDEE and PAEE in groups.[101]

Clinical Data

Electronic and paper charts from the university hospital's transplant clinic were used to gather demographic information and clinical data at baseline, 3 and 6 months and entered into the database for the larger longitudinal prospective study. Demographic information included age, gender, race/ethnicity, education level and socioeconomic information. Clinical data included date of transplant, number of hospitalizations following transplant, immunosuppressant medications, pre-transplant history and diabetes and hypertension and post transplant diabetes. Other data gathered included weight and BMI at baseline, 3 and 6 months following transplant.

Data Analysis

Data analysis was accomplished through the use of the SPSS/PSAW version 18.0. The dietary data were downloaded from NDS-R into an Excel spreadsheet for data cleaning. Activity data were downloaded from a database used for activity data storage was downloaded into an Excel spreadsheet. The data were then downloaded into SPSS/PSAW v. 18 for analysis. Descriptive statistics will be used to describe the participants with frequency distributions used to describe categorical data such as age, gender, race and clinical data. Repeated measures ANOVAs were used to compare nutrient changes and physical activity changes from baseline to 3 months to 6 months. Pearson's correlations were run on the dietary intake variables, physical activity variables and age, gender, race and immunosuppressant medications to check for relationships of these variables to weight gain. Data management included keeping all hard copies of data in a locked cabinet with only participant identification numbers. Computers storing data are password protected. NDS-R data is automatically saved every 24 hours in the system.

Research Questions

Question 1. Do transplant recipients increase their food and calorie intake following transplantation, and if so, how? Nutrient intake at baseline, 3 and 6 months were obtained through 24-hour dietary recalls and entered into NDS-R. Caloric intake was automatically calculated using NDS-R software for analysis. Repeated measures ANOVA was performed to examine the differences in nutrient intake at the three time points. Descriptive statistics were used to characterize the sample at the various time points. An a priori significance of ≤ 0.01 was used with the ANOVA to reduce the risk of type I error.

Question 2. Do transplant recipients increase their physical activity following transplant and, if so, at what time point? 7D PAR recalls were obtained at baseline, 3 and 6 months via face to face report or telephone recalls. Repeated measures ANOVA was performed to examine the differences in physical activity at the three time points. Descriptive statistics were used to characterize the sample at the three time points. An a priori significance of ≤ 0.01 was used with the ANOVA to reduce the risk of type I error.

Question 3. What is the relationship among diet, physical activity, and other factors (i.e., medications, race, age, gender) to weight gain in post kidney transplant recipients? Pearson's correlations were run on the dietary intake variables, physical activity variables and age, gender, race and immunosuppressant medications to check for relationships in these variables to weight gain. This was done to examine if there is a relationship in these variables and weight gain following kidney transplantation.

CHAPTER 4. RESULTS AND CONCLUSIONS

Introduction

Weight gain following kidney transplantation is a significant issue. Fifty to 90% of renal transplant recipients gain weight after transplant,[2] with an average first year weight gain of 22.7 to 25.0 pounds (10.3 to 11.8 kg).[3,4] Data from a retrospective review examining weight gain and changes in body mass index (BMI) categories during the first year following renal transplantation in our transplant center demonstrated a significant increase in weight of 13.6 to 70.4 pounds (6.2 kg to 32 kg).[7] This is significantly more than the 1.8-2 pounds (approximately 0.9 kg) average yearly weight gain reported in adults in the United States[121] and the recommended lifetime increase of < 11 pounds (5 kg).[122]

Undoubtedly, obesity can be attributed to environmental factors such as increased energy intake of kilocalories and decreased physical activity or expended energy.[121] In much the same way, it is believed that kidney transplant recipients increase their intake of kilocalories due to an increase in appetite and removal from dietary restrictions imposed in the management of chronic renal disease prior to transplantation, but do not increase their physical activity appreciably following transplantation. However, there is little documented about the food intake and physical activity levels of kidney transplant recipients and the relationship of these environmental factors to weight gain.

Improved allograft outcomes have resulted from advances in immunosuppressant therapies.[62] As a result of improved appetite[123] following renal transplantation, these individuals are at risk for weight gain leading to obesity.[23] Increased risk for cardiovascular disorders is often attributed to obesity following kidney transplantation,[30] and presently, the leading cause of death following kidney transplantation is cardiovascular disease.[124] Past research has targeted allograft rejection and advances in immunosuppressive medication regimes to preserve the newly transplanted kidney. With post transplant obesity and cardiovascular related issues being prevalent following transplant, the focus of transplant research should now focus on clinical nutrition.[1]

The purpose of this study was to examine dietary intake and physical activity of kidney transplant recipients at baseline, 3 and 6 months following transplantation to identify factors contributing to weight gain. The following research questions were asked: (1) Do kidney transplant recipients increase their food and calorie intake following transplantation, and if so, to what extent and at what time point? (2) Do kidney transplant recipients increase their physical activity following transplant and, if so, to what extent and at what time point? (3) What is the relationship of dietary intake, physical activity, and other factors (i.e., age, gender, race, medications) to weight gain in kidney transplant recipients?

An increased awareness of the factors leading to weight gain following kidney transplantation will facilitate the development of interventions to aid in the prevention of

significant weight gain. A greater understanding of the environmental factors leading to weight gain following kidney transplantation will assist health care professionals in the development of tailored dietary and physical activity protocols to lessen or ameliorate significant weight gain leading to obesity following kidney transplantation.

Methods

This descriptive, correlational study included secondary data to examine dietary intake, physical activity and other variables (e.g., age, gender, race, immunosuppressant medications) associated with weight gain post-kidney transplant. After obtaining institutional review board approval, dietary intake, physical activity and clinical data were used from participants enrolled in a larger, longitudinal study exploring environmental and genetics factors and their association to weight gain and obesity after kidney transplantation. The participants in the parent study were transplanted between August 2007 and August 2009 at a large Mid-south university-hospital-based transplant institute. The inclusion criteria for the parent study included (1) 18 years of age or older and (2) able to read and understand English. Exclusion criteria for the parent study were (1) receiving steroid therapy prior to the time of transplantation and (2) death or loss of allograft.

Forty-eight participants who had reached their 6 month time point and had baseline, 3 and 6 month dietary, physical activity and weight data were considered for the secondary data analysis. Participants were excluded if they lost greater than 10% body weight from baseline to 6 months. Blackburn and colleagues[109] identified weight loss greater than 10% in a 6 month period as significant. This percent weight change, usually accompanies poor oral intake or medical illnesses,[110] and indicates a state of protein malnourishment, impacting immune functioning, morbidity and mortality.[109] This study looked at dietary intake, physical activity and age, gender, race, and immunosuppressant medications and their association to weight gain, thus excluding the four participants who had lost greater than 10% body weight in the first 6 months following kidney transplantation.

Four participants (1 African American male, 1 African American female, 1 Caucasian male, 1 Caucasian female) were excluded because they had lost more than 10% of their baseline body weight at 6 months. Thus, 44 participants (22 males and 22 females) who had signed informed consent for the parent study and had reached their sixth month time point since transplantation were included in this secondary data analysis.

Data Collected/Procedure

For the parent study dietary intake, physical activity, heights, weights and BMI were obtained from all participants at the time of transplant (baseline) and 3 and 6 months following transplantation. Dietary intake and physical activity recalls were done by the same research team members who were well versed in gathering recall data.

Heights, weights and BMI were measured and recorded by the transplant clinic personnel in the electronic health record at the time of transplant and at 3 and 6 month check-ups following transplantation. The same calibrated medical scales were used to weigh participants at each time interval in the transplant clinic. Other clinical data collected from the database included kidney donor sources, numbers of hospitalizations in the first six months following transplantation, suspected rejection episodes, baseline incidence of hypertension and diabetes, and immunosuppressant medications.

Using telephone interviews, dietary and physical activity recalls were obtained after the first two weeks following transplantation. This period of time was considered to be reflective of the return to regular eating patterns while physical activity recall to be representative of activity and exercise engaged in the period just prior to transplantation.

Most of the recall interviews were conducted over the telephone or during regularly scheduled appointments in the transplant clinic. Twenty-four hour dietary intake was obtained at baseline and at 3 and 6 months following transplantation to include one weekend day and two weekdays of food and fluid. Physical activity at baseline and at 3 and 6 months was done by telephone recall using a 7 day recall of the past week's activity along with usual activity of the past 3 months. Age, gender, race and immunosuppressant medications were obtained by reviewing chart information.

Dietary Intake

This study used the Nutrition Data System for Research (NDS-R) to assess dietary intake at baseline, and at three and six months. Data were downloaded from the parent study database The NDS-R, developed by the Nutrition Coordinating Center at the University of Minnesota is a windows-based dietary analysis program used for entry and analysis of dietary intake. Considered the "gold standard" for dietary analysis, it contains data for 160 nutrients and food constituents, updated yearly to reflect changes in nutrient composition of foods and food market changes.[91]

To evaluate validity and reliability, quality control measures to verify data entry of various food sources, need to part of a data system.[92] Reviewing the system's manual, editing any improperly entered data or data in error, consistency of the program among the nutrient values of foods that are similar and consistency of nutrient contents within foods are automatic quality control features in NDS-R. Data consistency is also maintained by comparing nutrient values to algorithms of expected food values.[92] If discrepancies are found between the calculated algorithms, and what is contained in the database, nutrient ranges are flagged and investigated by NCC personnel. Still another means of validity and reliability is demonstrated by the number of reviews of the data. The first review is with the participant, the second occurs when the investigator reviews the data following the interview and the third is by confirming amounts on any data entry errors. Standardization of food portions through the use of common household measurements such as measuring cups and rulers also increase validity and reliability of the data received and entered.

Physical Activity

This study used the 7Day-Physical Activity Report (7D-PAR) to assess physical activity at baseline and at three and six months following kidney transplantation. The 7D-PAR is an instrument for gathering self-reported physical activity recall from participants through the use of interview, either face to face or per telephone. Based on participants' response to 7D-PAR recalls, five subsets of physical activity (sleep, light, moderate, hard and very hard) were studied to see if physical activity changed from baseline to 3 and 6 months and if so, when this change in physical activity was reflected following kidney transplantation. Kilocalories for the five subsets of activity were recorded as well as total METs compared from each time point. In addition, number of days of moderate activity was recorded. Moderate, hard or very hard exercise performed continuously for at least ten minutes was recorded.[100]

Test-retest reliability (r = 0.77, p ≤ 0.0001) was reported by Sallis and his team[117] in a cohort of children and adolescents. While comparing interviewers completing a five session group training program, Gross and colleagues reported a test reliability of r = 0.99 in healthy individuals while testing the skills of interviewers.[118] Convergent validity (r = 0.70, 0.66, p ≤ 0.05) examination was done comparing 7D-PAR with activity logs of men ages 34-60 years.[119]

Data Analysis

Dietary intake, entered into a windows-based dietary analysis program during the parent study was downloaded from the database. Data cleaning involved inspecting for outliers. Any questionable data such as excessive amounts of nutrient intake were verified by first checking the original document where data was recorded and comparing it to data entered into the nutritional database for analysis.

Physical activity data were downloaded from the storage database for the parent study into an Excel spreadsheet before importing into SPSS for analysis. Cleaning the data involved inspecting for outliers. Any questionable data such as excessive amounts of physical activity were verified by first checking the original 7D-PAR interview document where data were recorded and comparing it to data entered into the database for analysis.

Descriptive statistics and analysis of variance (ANOVA) for repeated measure were used to compare dietary intake and physical activity data at baseline with 3 and 6 months. This was done to determine if differences occurred in nutrient intake and physical activity following transplantation and if so, when. Pearson product moment correlations were used to identify relationships between dietary intake, physical activity and other variables (i.e. age, race, gender and immunosuppressant medications) to weight gain from baseline to 3 and 6 months. Statistical analyses were performed using Statistical Package for the Social Sciences, Predictive Analytic Software 18 for Windows (SPSS/PAW v.18.0). Values of p < 0.05 were considered statistically significant.

Results

Characteristics of the Sample

Forty four kidney transplant recipients were included in the study. Participant characteristics at baseline are reflected in Table 4.1.

Mean weight and mean BMI for this group stayed relatively constant from baseline to 3 months, with an increase in 6 months. Data in Table 4.2 demonstrate increase in weight, BMI and percent change in both from baseline to 6 months. Mean weight increased by 9.63 lbs (4.40 kg) and mean BMI showed an increase of 1.47.

Table 4.3 reflects weight by gender and race. More weight was gained by African American males and females, which was comparable, followed by Caucasian males. Caucasian females gained the least amount of weight during the 6 months following transplantation.

At the time of transplant mean creatinine and blood urea nitrogen (BUN) were 5.96 ± 2.89 mg/dL and 36.45 ± 15.42 mg/dL, respectively. Mean hemoglobin at the time of transplant was 11.31 ± 1.56 gm/dL. Co-morbid conditions pre-transplant were diabetes mellitus (n = 10, 21%) and hypertension (n = 44). All transplant recipients received immunosuppression with prednisone at the time of transplant (Table 4.4). Additional immunosuppression given was MMF, tacrolimus and sirolomus. One participant was receiving Imuran at baseline, two participants at 3 months and 4 participants at 6 months were receiving Imuran in addition to other immunosuppressant medications. The majority of participants received 20 mg daily of prednisone at baseline and were tapered to 5 mg daily by 3 months post transplantation (Table 4.5).

Data in Table 4.6 demonstrate the incidence of suspected rejection episodes and the number of hospitalizations following transplantation during the first 6 months after transplantation (not including the initial hospitalization for transplantation). Seven participants (16%) experienced suspected rejection episodes of which one was confirmed with biopsy post transplant. Hospitalizations post transplant were varied in number and causes.

Dietary Intake

There were no significant differences noted between time points for kilocalorie and nutrient intakes (Table 4.7). However, kilocalories for the group were about 25% lower than recommended. Of the macronutrients, total protein was around 25% lower than recommended, while total fat was about 100% more and total carbohydrate was about 50% more than recommended. Percent calories from fat was about 23% higher

Table 4.1   Participant characteristics at baseline (time of transplant) (n = 44).

Characteristic	Baseline (percent)
Age at transplantation years (mean, SD)	49.70 ± 13.09
Range, years	19-70
Males n (percent)	22 (50%)
Ethnicity n (percent)	
African American	26 (59)
Caucasian	18 (41)
Donor source n (percent)	
Cadaveric	33 (73)
Living related donor	10 (23)
Diabetes Mellitus	10 (21)
Hypertension	40 (92)

Table 4.2   Weight and body mass index (BMI) at baseline, 3 and 6 months (n = 44).

Weight/BMI	Baseline	3 Month	6 Month	Percent change baseline to 6 mo
Weight (lbs)	172.46 ± 34.05	171.21 ± 38.63	182.09 ± 38.38	6%
Weight range (lbs)	127-240	112-242.	118.8-255.9	
BMI (kg/m^2)	26.4 ± 3.8	26.79 ± 3.92	28.24 ± 4.17	5%
BMI (kg/m^2) range	19.47-33.47	19.84-34.85	21.30-38.98	

Abbreviations: BMI, Body Mass Index; M, male; F, female; lbs, pounds; kg/m^2, kilograms per meter squared.

Table 4.3 Weight and BMI at baseline, and at 3 and 6 months post transplant by race and gender (n = 44).

Weights/BMI	Baseline African American		3 Months African American		6 Months African American		Baseline Caucasian		3 Months Caucasian		6 Months Caucasian	
	M	F	M	F	M	F	M	F	M	F	M	F
Weight (lbs)	180.10 ± 27.97	147.14 ± 18.75	181.13 ± 35.34	145.25 24.15 ±	191.10 ± 33.04	158.89 ± 26.06	212.31 ± 22.70	152.10 ± 20.34	213.07 ± 28.25	149.21 ± 23.67	221.66 ± 31.78	155.50 ± 22.93
Weight range (lbs)	133-223	117-185	140-236	112-191	152-232	128-208	155-240	133-185	146-242	131-192	148-256	133-197
BMI (kg/m^2)	26.52 ± 1.65	25.02 ± 3.43	26.69 ± 3.45	25.43 ± 4.60	28.19 ± 3.0	27.21 ± 5.33	29.21 ± 1.98	27.06 ± 2.76	28.79 ± 3.62	26.70 ± 3.18	30.03 ± 4.07	26.70 ± 3.18
BMI (kg/m^2) range	25.14-29.15	19.47-31.71	21.92-29.80	19.84-33.73	23.80-33.08	21.30-38.98	26.72-33.47	24.31-31.82	20.99-32.82	24.14-31.82	21.25-34.70	24.30-32.20
Δ in lbs baseline to 6 mo					11.1	11.7					9.3	2.4
Percent wt Δ baseline to 6 mo					7	8					4	2

Abbreviations: BMI, Body Mass Index; M, male; F, female; lbs, pounds; kg/m^2, kilograms per meter squared; mo, month; wt, weight; Δ, change.

Table 4.4   Frequency of prednisone dosages at baseline, and at 3 and 6 months posttransplant (n = 44).

Dosage	Baseline	3 Months	6 Months
50 mg	n = 1	n = 0	n = 0
20 mg	n = 35 (73%)	n = 0	n = 0
15 mg	n = 6	n = 1	n = 1
12 mg	n = 0	n = 0	n = 1
10 mg	n = 4	n = 3	n = 1
5 mg	n = 2	n = 42 (89%)	n = 40 (85%)
2.5 mg	n = 0	n = 0	n = 2
0 mg	n = 0	n = 1	n = 1
Missing	n = 0	n = 1	n = 2

Table 4.5   Immunosuppression medications by time period (n = 44).

Medication	Baseline	3 Months	6 Months
Prednisone	n = 44 (91%)	n = 44 (91%)	n = 42 (95%)
Mycophenolate	n = 43 (98%)	n = 40 (91%)	n = 41 (93%)
Tacrolimus	n = 38 (86%)	n = 44 (100%)	n = 41 (93%)
Sirolimus	n = 1 (2%)	n = 2 (5%)	n = 4 (9%)
Immuran	n = 1 (2%)	n = 2 (5%)	n = 4 (9%)

Table 4.6   Hospitalizations and suspected rejection episodes (n = 35).

Hospitalization/Rejection episode	From baseline to 6 months n (%)
Hospitalizations	32 (73)
Rejection episodes	7 (16)
Confirmed no with biopsy	6 (86)
Confirmed yes with biopsy	1 (14)

Table 4.7   Nutrient intake at baseline to 3 and 6 months posttransplant (n = 44).

Nutrient	Baseline	3 Months	6 Months
Kilocalorie	1709.1 ± 566.4	1747.6 ± 608.2	1638.1 ± 531.3
Total fat (g)	70.0 ± 23.4	75.4 ± 28.2	69.1 ± 25.7
Total CHO (g)	202.1 ± 86.8	193.8 ± 85.2	188.9 ± 71.4
Total protein(g)	72.2 ± 22.5	76.8 ± 24.8	69.0 ± 19.7
Cholesterol	292.7 ± 117.3	320.0 ± 158.0	293.9 ± 161.3
Total fiber	12.3 ± 6.1	12.9 ± 5.9	12.7 ± 5.6
Vitamin D	3.73 ± 3.7	5.00 ± 7.1	3.26 ± 1.8
Vitamin C	55.4 ± 38.8	50.5 ± 33.9	54.1 ± 40.7
Calcium	566.6 ± 253.7	605.7 ± 278.9	558.5 ± 62.5
Phosphorus	1016.3 ± 347.0	3 ± 390	971 ± 300.1
Sodium	3134 ± 922.2	3306.6 ± 1290.8	2981.1 ± 248.1
Potassium	2018.3 ± 976.6	1968.5 ± 749.9	1862.1 ± 82.3
% Calories fat	36.8 ± 6.7	36.8 ± 6.7	37.1 ± 5.6
% Calories CHO	45.9 ± 8.2	43.6 ± 8.3	45.0 ± 7.15
% Calories prot	17.7 ± 4.0	18.5 ± 5.1	17.9 ± 4.4
Omega-3 FAs	1.5 ± .7	1.8 ± 1.1	1.3 ± .6

Abbreviations: CHO, carbohydrate; prot, protein; cal, calories; FAs, fatty acids; g, gram; mcg, microgram; mg, milligram.
Note: No significant differences were found in time points.

while percent calories from carbohydrate was around 10% less than suggested. Cholesterol intake was in line with recommended intake, while fiber was about 50% less than recommended.

Of the micronutrients, vitamins D and C, calcium, phosphorus and potassium were roughly 50% lower than suggested values, while sodium was around 36% higher than what is recommended. Omega-3 fatty acid intake was in line with recommended intake values. Table 4.8 shows the percent of participants at or above the DRI for each nutrient variable at baseline, 3 and 6 months.

Table 4.9 demonstrates significance by race and gender, showed kilocalorie intake higher in males of both races than females at all time points ($p \leq 0.05$). AA males and females had higher kilocalorie intakes than Caucasians at baseline and 3 months and fairly comparable intakes at 6 months.

Total fat intake was higher in males from baseline to 3 months ($p \leq 0.035$). AA males and Caucasian males had the highest mean intake of fat and are fairly comparable between the two groups of male participants. AA females have a higher fat intake compared to Caucasian females. Means for total fat intake were higher in AAs than in Caucasians.

Total carbohydrate intake showed higher intakes in males from baseline to 3 months ($p \leq 0.048$). Carbohydrate intake was higher in males of both races compared to females of both races. Mean carbohydrate intake was higher in Caucasian males than AA males and higher in AA females than in Caucasian females.

No statistical significance was demonstrated in total protein intake according to race and gender. Higher mean protein intakes were seen at all time points in AA males compared to Caucasian males and higher in AA females than in Caucasian females. Higher mean total intake of protein was seen in AA males at all time points.

Cholesterol intake was higher from baseline to 3 months and according to race ($p \leq 0.012$) and gender ($p \leq 0.004$). Higher mean intake for cholesterol was seen in AA males compared to Caucasian males and AA and Caucasian females. According to race and gender, AA males and females have higher mean cholesterol intakes than Caucasian females.

Total fiber intake was higher according to race ($p \leq 0.035$) and significance according to gender ($p \leq 0.067$). Mean for total fiber intake was higher in Caucasian race than in AA race. Mean total fiber intake was higher in Caucasian males than in Caucasian females and higher in AA males compared to AA females.

Micronutrient intake of vitamin D and vitamin C were not statistically significant. However, calcium intake showed for race ($p \leq 0.045$), gender ($p \leq 0.003$) and race and gender ($p \leq 0.015$). Caucasians had higher mean intake of calcium at all time points compared to AA participants. Males (both races) had higher mean intake of calcium than

Table 4.8   Percent at or above Daily Recommended Intake for nutrients (n = 44).

Nutrient	Time point	Daily recommended intake (DRI)	Percent at or above DRI
Kilocalorie	Baseline	30 kcal/kg weight	9
	3 months	28 kcal/kg weight	7
	6 months	28 kcal/kg weight	4
Total fat	Baseline	35 grams	98
	3 months	35 grams	93
	6 months	35 grams	91
Total CHO	Baseline	130 grams	82
	3 months	130 grams	73
	6 months	130 grams	86
Total protein	Baseline	1.2 grams/kg weight	23
	3 months	0.8 grams/kg weight	70
	6 months	0.8 grams/kg weight	57
Cholesterol	Baseline	< 130 grams	91
	3 months	< 130 grams	91
	6 months	< 130 grams	84
Total fiber	Baseline	25-30 grams	5
	3 months	25-30 grams	5
	6 months	25-30 grams	5
Vitamin D	Baseline	10 micrograms	7
	3 months	10 micrograms	9
	6 months	10 micrograms	0
Vitamin C	Baseline	70 milligrams	36
	3 months	70 milligrams	23
	6 months	70 milligrams	23
Calcium	Baseline	800-1000 milligrams	18
	3 months	800-1000 milligrams	18
	6 months	800-1000 milligrams	14

Table 4.8   (continued).

Nutrient	Time point	Daily recommended intake (DRI)	Percent at or above DRI
Phosphorus	Baseline	1200-1500 milligrams	23
	3 months	1200-1500 milligrams	25
	6 months	1200-1500 milligrams	20
Sodium	Baseline	1000-3000 milligrams	100
	3 months	1000-3000 milligrams	100
	6 months	1000-3000 milligrams	100
Potassium	Baseline	1000-3000 milligrams	93
	3 months	1000-3000 milligrams	89
	6 months	1000-3000 milligrams	89
Percent calories fat	Baseline	30 %	84
	3 months	30 %	93
	6 months	30 %	86
Percent calories CHO	Baseline	50%	43
	3 months	50%	20
	6 months	50%	18
Percent calories protein	Baseline	20%	16
	3 months	20%	23
	6 months	20%	32
Omega-3 fatty acids	Baseline	1.10 milligrams	75
	3 months	1.10 milligrams	66
	6 months	1.10 milligrams	57

Abbreviations: kcal, kilocalorie; CHO, carbohydrate; kg, kilogram

Table 4.9   Nutrient intake by race and gender at baseline, 3 and 6 months and total (n = 44).

Nutrient/ Threshold	Time point	African American Male (n = 11)	Female (n = 15)	Caucasian Male (n = 11)	Female (n = 7)
Kilocalorie	Bl	1652.3 ± 296.2	1849.9 ± 754.2	1753.9 ± 621.0	1426.4 ± 174.5
30 kcal/kg wt. bl	3 mo	1928.1 ± 288.6	1668.9 ± 643.7	1883.3 ± 667.4	1419.6 ± 482.6
28 kcal/kg wt. (3 & 6 mo)	6 mo	1802.4 ± 288.6*	1442.0 ± 662.8	1882.2 ± 524.6*	1416.5 ± 4
Total fat (g)	Bl	71.4 ± 29.1	72.9 ± 27.5	71.1 ± 29.1	60.1 ± 10.1
35 g	3 mo	83.3 ± 24.0*	75.2 ± 30.3	78.6 ± 28.3*	58.8 ± 28.5
	6 mo	79.0 ± 19.7	60.1 ± 26.0	78.8 ± 28.5	57.6 ± 26.0
Total carbohydrate (g)	Bl	176.9 ± 40.1	225.6 ± 115.6	220.9 ± 91.4	161.8 ± 35.0
	3 mo	216.7 ± 85.6*	173.2 ± 86.9	221.3 ± 95.9*	158.6 ± 45.2
130 g	6 mo	199.2 ± 44.0	166.3 ± 92.1	223.0 ± 68.0	168.0 ± 40.4
Total protein(g)	Bl	77.4 ± 24.9	76.9 ± 24.4	66.1 ± 22.4	63.6 ± 9.5
1.2g/kg wt. bl	3 mo	81.4 ± 22.1	76.9 ± 23.5	77.2 ± 23.5	68.8 ± 34.4
0.8g/kg wt. (3 & 6 mo)	6 mo	76.9 ± 10.5	61.1 ± 21.0	76.6 ± 22.7	61.8 ± 17.1
Cholesterol	Bl	324.4 ± 36.0	294.0 ± 45.2	282.3 ± 36.0	256.4 ± 45.2
< 130 g	3 mo	368.7 ± 168.0*	330.6 ± 144.6*	292.3 ± 124.7*	264.2 ± 217.2
	6 mo	337.8 ± 201.2	330.4 ± 201.2	248.6 ± 117.1	217.9 ± 135.8
Total fiber	Bl	11.2 ± 3.5	11.8 ± 7.0	15.1 ± 7.8	10.7 ± 5.0
25-30g	3 mo	12.4 ± 4.4	10.1 ± 6.0	15.7 ± 5.0	15.1 ± 7.0
	6 mo	13.7 ± 5.0	9.4 ± 5.3	16.0 ± 4.7	12.6 ± 6.0

Table 4.9   (continued).

Nutrient/ Threshold	Time point	African American		Caucasian	
		Male (n = 11)	Female (n = 15)	Male (n = 11)	Female (n = 7)
Vitamin D (mcg)	Bl	4.2 ± 1.9	2.8 ± 1.4	2.8 ± 1.3	2.6 ± 1.6
10 mcg	3 mo	4.2 ± 1.9	7.3 ± 10.5	4.2 ± 1.9	5.0 ± 8.4
	6 mo	4.1 ± 1.7	2.7 ± 1.6	3.7 ± 1.9	2.4 ± 1.6
Vitamin C (mg)	Bl	45.9 ± 24.2	52.3 ± 41.5	54.1 ± 42.4	78.8 ± 44.0
70 mg	3 mo	54.1 ± 39.7	51.6 ± 37.0	47.8 ± 31.2	46.6 ± 27.0
	6 mo	56.0 ± 49.2	45.2 ± 34.2	63.5 ± 41.6	55.5 ± 40.1
Calcium (mg)	Bl	546.1 ± 193.2	536.4 ± 269.6	702.7 ± 315.0	449.9 ± .9
800-1000mg	3 mo	568.4 ± 199.3	515.7 ± 272.0	836.8 ± 316.3	494.3 ± 128.9
	6 mo	486.1 ± 99.7	843.3 ± 327.7	843.3 ± 327.7	470.6 ± 129.4
Phosphorus (mg)	Bl	1041.6 ± 755.7	2.0 ± 414.7	1029.9 ± 419.6	878.3 ± 179.2
1200-1500mg	3 mo	1019.5 ± 294.5	1027.8 ± 421.9	1198.6 ± 404.5	930.9 ± 1655.2
	6 mo	3.5 ± 232.6	834.6 ± 277.6	1173.1 ± 315.0	815.7 ± 219.9
Sodium (mg)	Bl	3157.54 ± 801.9	3241.0 ± 1043.3	3131.3 ± 910.43	2871.6 ± 996.5
1000-3000 mg	3 mo	3521.2 ± 1157.7	3109.4 ± 1276.2	3663.0 ± 1222.3	2831.8 ± 1655.2
	6 mo	3254.2 ± 482.3*	2553.5 ± 1.8	3652.0 ± 1817.7	2414.22 ± 945.2
Potassium (mg)	Bl	1817.6 ± 971.5	1928.8 ± 971.5	2386.6 ± 1326.2	1947.1 ± 829.9
1000-3000 mg	3 mo	1727.1 ± 490.0	1899.9 ± 641.0	2201.2 ± 659.1	2128.6 ± 1303.6
	6 mo	1955.2 ± 673.0	1581.9 ± 647.2	2260.5 ± 581.67	1690.0 ± 708.8

Table 4.9   (continued).

Nutrient/ Threshold	Time point	African American		Caucasian	
		Male (n = 11)	Female (n = 15)	Male (n = 11)	Female (n = 7)
Percent calories fat	Bl	38.2 ± 6.4	36.4 ± 6.3	36.2 ± 9.0	36.4 ± 4.7
30%	3 mo	37.9 ± 4.7	39.3 ± .3	37.3 ± 4.6	35.5 ± 5.9
	6 mo	39.0 ± 6.0	37.1 ± 4.3	36.0 ± 7.4	35.5 ± 4.2
Percent calories CHO	BL	42.6 ± 8.2	46.4 ± 7.8	48.6 ± 9.3	45.8 ± 7.3
50%	3 mo	43.9 ± 8.2	41.2 ± 10.0	46.0 ± 5.7	44.6 ± 8.1
	6mo	43.5 ± 5.1	43.5 ± 6.2	47.5 ± 8.5	47.0 ± 7.8
Percent calories	Bl	19.2 ± 4.7	18.0 ± 4.2	15.5 ± 2.6	18.0 ± 3.4
protein	3 mo	18.1 ± 4.8	19.4 ± 5.7	16.9 ± 2.4	20.0 ± 7.5
20%	6 mo	17.45 ± 2.5	19.4 ± 5.9	16.5 ± 3.2	17.6 ± 4.4
Omega-3 fatty acids	Bl	1.2 ± 0.5	1.7 ± 0.9	1.5 ± 0.7	1.7 ± 0.6
(mg)	3 mo	1.5 ± 0.4	2.1 ± 0.8*	1.7 ± .8	1.9 ± 2.0*
1.10 mg	6 mo	1.4 ± 0.4	1.1 ± 0.6	1.6 ± .7	1.1 ± 0.3

*$p < 0.005$ between groups with like symbols.

Abbreviations: kcal/kg wt, kilocalories per kilogram body weight; mo, month; g, grams; Bl, baseline; mcg, micrograms; mg, milograms; CHO, carbohydrate.

females (both races) at all time points. Caucasian males had higher mean intakes of calcium at all time points than Caucasian females and AA males had higher mean intake of calcium than AA females at all time points. Mean phosphorus intake was higher in males than females ($p \leq 0.037$). Mean sodium intake showed higher intakes in males of sodium than females ($p \leq 0.034$). Similarly, mean intake of potassium was higher in males than in females ($p \leq 0.029$).

Percent calories from fat, carbohydrates and protein did not show statistical significance. However, Omega-3 fatty acid intake was higher from 3 month to 6 months ($p \leq 0.010$) in gender ($p \leq 0.018$). Mean intake of omega 3 fatty acid was higher in females than males from baseline to 3 months.

Physical Activity

A significant decrease was seen in mean hours of sleep from baseline to 6 month in pairwise comparisons ($p \leq 0.02$). Other physical activity variables did not show significance for the total group (Table 4.10).

Table 4.11 demonstrates physical activity by race and gender. Hours per day of light activity did not show significance. However, moderate activity was significant related to gender from 3 months to 6 months ($p \leq 0.046$). Mean hours per day of moderate activity decreased in males from 3 months to 6 months, whereas moderate activity for females increased from 3 months to 6 months.

Hours per day of hard activity was significant from 3 months to 6 months ($p \leq 0.04$) according to race and gender. Mean increases from 3 months to 6 months were seen in Caucasian females. Hours per day of very hard activity was not reported by any participants.

Kilocalories for sleep were not significant. Kilocalories for light activity showed increased kilocalories for light activity in males from 3 months to 6 months ($p \leq 0.028$). Mean increases were seen in males from 3 months to 6 months. Females stayed comparable at all time points. Kilocalories for moderate and hard activity were not statistically significant.

Total METs did not show statistical significance. Similarly the number of days of moderate activity reported in a 7 day period did not show statistical significance.

Relationship between Dietary Intake and Weight Gain

Pearson's product correlation showed no statistical association between weight gain at 6 months and kilocalories and macro and micronutrient intake at baseline to 3 and 6 months except for 6 month vitamin D ($p \leq 0.003$) (Tables 4.12–4.14).

Table 4.10   Physical activity from baseline to 6 months (n = 44).

Activity variable	Baseline	3 Months	6 Months
Hours/day sleep	8.3 2.0*	7.9 ± 1.6	7.4 ± 1.9*
Hours/day light	15.4 ± 2.4	15.5 ± 1.8	15.6 ± 2.7
Hours/day moderate	0.4 ± 0.9	0.5 ± 0.8	0.4 ± 0.9
Hours/day hard	0.04 ± 0.26	0.02 ± 0.1	0.07 ± 0.38
Hours/day very hard	0	0	0
Kilocalories/sleep	8.3 ± 2.0	7.9 ± 1.6	7.4 ± 1.9
Kilocalories/light	23.1 ± 3.7	23.3 ± 2.7	24.0 ± 2.7
Kilocalories moderate	1.2 ± 2.6	1.7 ± 2.7	1.3 ± 2.7
Kilocalories hard	0	0	0
Kilocalories very hard	0	0	0
Number of days moderate activity†	1.9 ± 2.0	2.3 ± 2.5	2.1 ± 2.2
Total METs	32.7 ± 2.2	32.7 ± 2.4	33.3 ± 7.2

*Mean difference is significant at the .05 level when adjusted for multiple comparisons
using Bonferroni between time points with like symbols.

†Number of days of at least 30 minutes of moderate or harder physical activity per week.

Table 4.11 Physical activity at baseline, 3 and 6 months according to race and gender (n = 44).

Variable act	Baseline African American		3 Months African American		6 Months African American		Baseline Caucasian		3 Months Caucasian		6 Months Caucasian	
	M	F	M	F	M	F	M	F	M	F	M	F
Hrs/ day sleep	8 ± 2	8 ± 2	8 ± 1	8 ± 2	7 ± .9	7 ± 2	8 ± 2	9 ± 2	7 ± 1	8 ± 3	8 ± .8	8 ± 3
Hrs/ day light	16 ± 3	15 ± 2	16 ± 2	15 ± 3	16 ± 1	16 ± 3	15 ± 1	16 ± 4	16 ± 2	15 ± 3	15 ± 3	15 ± 4
Hrs/ day mod	.5 ± .9	.1 ± .2	.8 ± 1**	.3 ± .3*	.4 ± .3**	.3 ± .5*	.8 ± 1	.2 ± .3	.6 ± .5**	.7 ± 1.*	.2 ± .2**	1 ± 2*
Hrs/ day hard	.02 ± .04	.12 ± .44	0	0	.05 ± .12	0	0	0	.07 ± .21	.03 ± .08†	0	.40 ± .93†
Hrs/ day very hard	0	0	0	0	0	0	0	0	0	0	0	0
Kcal sleep	8 ± 2	8 ± 2	8 ± 1	8 ± 2	7 ± .9	7 ± 2	8 ± 2	9 ± 2	7 ± 1	8 ± 3	8 ± .8	8 ± 3
Kcal light	24 ± 4	23 ± 3	23 ± 2	24 ± 3	25 ± 1	24 ± 2	22 ± 2	24 ± 6	23 ± 3	23 ± 4	24 ± 1	22 ± 6
Kcal mod	2 ± 3	.40 ± .58	2 ± 4	1 ± 1	1 ± 1	1 ± 1	2 ± 4	.5 ± .9	2 ± 2	2 ± 3	.6 ± .6	4 ± 6

Table 4.11 (continued).

Variable act	Baseline African American		3 Months African American		6 Months African American		Baseline Caucasian		3 Months Caucasian		6 Months Caucasian	
	M	F	M	F	M	F	M	F	M	F	M	F
Kcal hard	0	0	0	0	0	0	0	0	0	0	0	0
Kcal very hard	0	0	0	0	0	0	0	0	0	0	0	0
Days mod	2 ± 1	2 ± 2	3 ± 2	2 ± 3	3 ± 2	2 ± 2	2 ± 2	2 ± 3	2 ± 1	3 ± 3	2 ± 2	3 ± 3
Total METs	32 ± 1	33 ± 2	33 ± 1	32 ± 3	33 ± .9	31 ± 8	33 ± 3	32 ± 2	33 ± 2	33 ± 3	35 ± 10	36±6

* Hours/day moderate activity significant in females.

**Hours/day moderate activity significant in males.

† Hours/day hard activity significant in Caucasian females.

Abbreviations: ACT, activity; AA, African American; M, male; F, female; lbs, pounds; kg/m^2, kilograms per meter squared; mo, month; Kcal, kilocalorie; Hrs/day, hours per day; mod, moderate; MET, metabolic equivalent.

Note: Mean difference is significant at the .05 level when adjusted for multiple comparisons using Bonferroni between timepoints with like symbols.

Table 4.12 Correlations between baseline dietary intake and weight gain at 6 months (n = 44).

Nutrient	Pearson correlation	P-value (2-tailed)
Kilocalorie	0.134	0.387
Total fat (g)	0.073	0.635
Total CHO (g)	0.149	0.334
Total protein (g)	0.151	0.328
Cholesterol	0.016	0.919
Total fiber	0.096	0.536
Vitamin D	-0.184	0.231
Vitamin C	0.034	0.827
Calcium	-0.001	0.996
Phosphorus	0.099	0.521
Sodium	0.174	0.324
Potassium	0.147	0.446
Percent calories fat	-0.124	0.422
Percent calories carbohydrate	0.077	0.619
Percent calories protein	0.044	0.777
Omega-3 fatty acids	-0.139	0.367

Note: None of the correlation coefficients is statistically significant at the 0.05 or 0.01 level for the 18 tests shown above.

Table 4.13 Correlations between 3 month dietary intake and weight gain at 6 months (n = 44).

Nutrient	Pearson correlation	P-value (2-tailed)
Kilocalorie	0.129	0.404
Total fat (g)	0.092	0.550
Total CHO (g)	0.138	0.371
Total protein (g)	0.099	0.522
Cholesterol	0.017	0.914
Total fiber	0.099	0.524
Vitamin D	.057	0.444
Vitamin C	0.201	0.191
Calcium	0.089	0.567
Phosphorus	0.070	0.653
Sodium	0.060	0.698
Potassium	0.058	0.706
Percent calories fat	-0.054	0.728
Percent calories carbohydrate	0.077	0.619
Percent calories protein	0.035	0.823
Omega-3 fatty acids	0.047	0.763

Note: None of the correlation coefficients is statistically significant at the 0.05 or 0.01 level for the 18 tests shown above.

Table 4.14 Correlations between 6 month dietary intake and weight gain at 6 months (n = 44).

Nutrient	Pearson correlation	P-value (2-tailed)
Kilocalorie	0.142	0.357
Total fat (g)	0.065	0.673
Total CHO (g)	0.148	0.338
Total protein (g)	0.217	0.156
Cholesterol	0.200	0.193
Total fiber	-0.011	0.944
Vitamin D	0.444	0.003*
Vitamin C	0.014	0.926
Calcium	0.166	0.282
Phosphorus	0.249	0.103
Sodium	0.026	0.865
Potassium	0.109	0.480
Percent calories fat	-0.165	0.285
Percent calories carbohydrate	0.102	0.510
Percent calories protein	0.050	0.749
Omega-3 fatty acids	0.080	0.606

*Correlation is significant at the 0.05 level (2-tailed).

Relationship between Physical Activity and Weight Gain

Data from Pearson's product correlation showed no statistical association in the physical activity variables and weight gain. However, African American race and gender were significantly associated with 6 month weight. Caucasian race showed a negative correlation with 6 month weight (r = 0.300, p ≤ 0.048). Female gender was also negatively correlated with 6 month weight (r = 0.633, p ≤ 0.000).

Relationship among Age, Gender, Race and Medications and Weight Gain

Data from Pearson's product correlation showed no correlation among age, gender, race and medications (Table 4.15) to weight gain. However, Spearman's rho showed correlation of 6 month MMF (p ≤ 0.041) and baseline tactrolimus (p ≤ 0.014) to weight gain. Percent weight change was significantly associated with 3 month BMI (p ≤ 0.001) and 6 month BMI (p ≤ 0.003).

Discussion

Weight gain after kidney transplantation has been well documented and is a risk factor for obesity and other co-morbid disorders. Previous studies[2,3,7] have shown a significant amount of weight gained in the first months to years after kidney transplantation. Weight gain leading to obesity in some participants make them vulnerable for cardiac disorders,[6] the number one cause of death in this population.[31]

In this study, kilocalorie intake was less than recommended in the total group at baseline, and at 3 and 6 months post-transplant. Total protein, although lower than suggested intake, was close to the recommended level at 6 months. Dietary intake was characterized by an increased total fat and total carbohydrate intake by the sample at the three time points but with less fiber than is recommended. This higher total fat and total carbohydrate intake is similar to findings in a study examining dietary intake in kidney transplant recipient three years after transplantation.[125] In contrast to our study, these researchers found that kilocalorie and protein intakes for their participants were generally adequate. Furthermore, these researchers were gathering dietary intake data 3 years following kidney transplant as opposed to during the first 6 months after transplantation as in our study.

Although similar in age (49.0 ± 12.8 years) and gender (44% female) to the participants in my study, those kidney transplant recipients that Heaf and colleagues[125] used to gathered dietary intake came from Denmark, as opposed to the southern region of the United States. Comparison of study participants related to socioeconomic status and access to nutritious foods was not possible.

However, just in Heaf and colleagues' findings,[125] higher intake of fat in males was similar to fat intake in males in our study. These are clinically significant findings

Table 4.15 Correlations of medications with weight gain in pounds (n = 44).

Medication time point	Pearson correlation	P-value (2-tailed)
Baseline prednisone	-0.164	0.287
Three month prednisone	-0.094	0.548
Six month prednisone	-0.144	0.363
Baseline tacrolimus	0.039	0.801
Three month tacrolimus	0.070	0.662
Six month tacrolimus	0.039	0.639
Baseline MMF	0.144	0.358
Three month MMF	0.050	0.766
Six month MMF	-0.045	0.778

Abbreviations: MMF, mycophenolate mofetil.

Note: None of the correlation coefficients is statistically significant at the 0.05 or 0.01 level for the 9 tests shown above.

that could place these transplant recipients at risk for accelerated atherosclerosis and cardiovascular morbidity as seen in other studies.

Similarly, researchers in Mexico report significantly higher ingestion of proteins and fats than recommended DRIs ($p \leq 0.05$) in kidney transplant recipients in eight states in Mexico. The highest fat intakes were in those states bordering the United States. It was thought that these findings reflected similar eating habits as the population in the United States. As would be expected, BMIs were higher in those transplant recipients with the higher intakes of proteins and fats compared to those with less dietary intake of these macronutrients.[17]

Sodium intake was higher than the recommendations at all time points which could contribute to post transplant hypertension. Since 92% of the participants in this study were hypertensive at baseline, sodium intake should be at a more conservative intake of 1 to 3 grams given that hypertension was still present post-transplant.[16] At the same time, these individuals could be at risk for hypertension due to the impaired sodium excretion effects of calcineurin inhibitors although less hypertensive effects are seen with tacrolimus.[107] Potassium intake was lower than recommended in our study and similar to others.[125] since potassium requirements are varied following transplantation. Lower potassium intakes in our participants could be attributed lower intakes of fruits and vegetables containing potassium. Another contributor to a lower potassium intake is recommendations by the transplant nephrologists for lower intake of potassium-rich foods since some of the immunosuppressant medications can contribute to hyperkalemia.

Also similar to findings of other researchers, participants in the current study consumed lower amounts of vitamin D[125] and calcium[126] which could be contributing factors to the development of osteoporosis and stress fractures. Similar to kidney transplant recipients in Denmark[127] and Ireland,[126] findings suggest, as in our study, that calcium and vitamin D intakes are inadequate following kidney transplantation in these samples. In a larger sample with a mean age of 53.6 ± 11.8 years, Ewers and colleagues[127] found that 81% of their sample was deficient in vitamin D and calcium.

Not only are these kidney transplant recipients prone to the development of osteoporosis and stress fractures due to the inadequate intake of vitamin D and calcium, increased weight gain could be a contributing factor to these conditions following kidney transplantation. Kamycheva and colleagues[128] in Norway found a significant association between calcium intake and BMI in males and an association between vitamin D intake and BMI in both genders. However, further studies need to be done to determine if there is an association between weight gain and vitamin D deficiency.

Similar to our study, these researchers noted a low intake of dairy products in their participants' dietary recalls, thus offering an explanation for the lower amounts of intake of vitamin D and calcium. One difference in food in Norway and the United States, is the lack of fortified foods with vitamin D in Norway, possibly explaining one reason for the lowered intake in that study sample.

Physical activity results suggest that for the most part, participants did not show significant variation over time in the physical activity subsets of sleep, light, moderate, hard and very hard activity. Similar to Nielens and colleagues[20]who studied activity levels in renal transplant recipients before transplant and at 1 year following transplantation, our findings indicate that the majority of the participants increased light activity post transplantation. Another similarity in our study and Nielens[20]was that hours per day for sleep decreased in their participants from baseline to one year, whereas participants in my study decreased the number of hours of sleep from baseline to 6 months. These findings suggest that some of the hours spent sleeping at baseline (perhaps related to their health status due to uremia prior to transplantation), are now being spent in light physical activities.

Unlike the study by Nielens,[20] my study did show that kilocalories for light activity indicated mean increased only in males from 3 to 6 months, with females remaining comparable at all time points. Also kilocalories for moderate and hard activity were not significantly different from each time point.

Although no significant relationships were demonstrated among dietary intake, physical activity and age, gender, race and immunosuppressant medications, clinical significance exists when reviewing the high amounts of total fat and carbohydrates at all time points. These higher macronutrient intakes, coupled with low levels of physical activity, could put these participants at risk for weight gain. It is also important to note that this group of participants also had low intakes of total fiber that could contribute to weight gain. Low levels of micronutrients (i.e., calcium, vitamin D) could put them at risk for bone deterioration following transplantation.

Similar to other studies, weight gain has been demonstrated in individuals who may have a genetic predisposition to weight gain related to ethnicity.[4,7,129] Although in our study African American males and females tended to gain more weight in the first 6 months after kidney transplant, a significant difference was not demonstrated as in other studies. Since African American participants gained more weight in this study than Caucasian males and females, these two groups could be more at risk for weight gain following kidney transplantation. Along with being at risk for obesity, this group of transplant recipients may also develop undesirable conditions such as CAD, hypertension, hyperlidemia and new onset diabetes mellitus.[2,1,62]

Limitations

Since the dietary intake and physical activity data are self-reported, there are some limiting factors associated with this type of data collection. Memory of the preceding 24 hour period for the dietary intake recall and the 7 days preceding the physical activity recall could be seen as limitations of this study.

Also, dietary baseline data, obtained approximately 2 weeks following kidney transplantation, could be different than data obtained in the weeks or months preceding

transplantation. Baseline physical activity data, also collected about 2 weeks following transplantation, reflects the participants' recall of their physical activity just prior to kidney transplantation.

Baseline steroid dosages were higher than at 3 and 6 months which could increase appetite during the first weeks following transplantation. Thus, steroid use during the early period following transplantation could have affected an increase in dietary intake.

A factor that may affect the generalizability of this study to a larger kidney transplant population is the small sample size. Furthermore, the study participants were not randomly selected but were all consented in a larger parent study from the same transplant center in the mid-south area representing participants from Tennessee, Arkansas and Mississippi, predominately.

Conclusions

Kidney transplant recipients are at risk for weight gain from a number of factors. However, little consideration has been given to what kidney transplant recipients are eating and the effect dietary intake has on weight gain in this population. High intakes of total fat and carbohydrates, along with low intake of fiber put these kidney transplant recipients at risk for co-morbid disorders as well. Physical activity data from this study suggest that kidney transplant recipients are not changing their physical activity levels significantly by 6 months following transplantation compared to their baseline activity levels.

The implications of these findings are that dietary assessments, including 24 hour dietary intake, and physical activity assessments should continue to be monitored for at least one year or longer following transplantation, to examine effects of dietary intake and physical activity on weight gain. Dietary and physical activity data from this study suggest the need for interventions to teach individuals who have undergone kidney transplantation, dietary and physical activity factors that could prevent weight gain in the post transplant period. Nurses, in collaboration with transplant dietitians and other members of the transplant team, can be instrumental in designing interventions that will accomplish short term goals of weight management, while employing gradual dietary changes in the levels of fat, carbohydrates and fiber that are more in line with recommended values. Along with these dietary intake changes, physical activity tailored to each transplant recipient could be developed and encouraged with follow-up during the intervention period.

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