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Longitudinal analysis of physical activity, fluid intake, and graft function among kidney transplant recipients

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Summary

Self-care is recommended to kidney transplant recipients as a vital component to maintain long-term graft function. However, little is known about the effects of physical activity, fluid intake, and smoking history on graft function. This longitudinal study examined the relationship between self-care practices on graft function among 88 new kidney transplant recipients in Chicago, IL and Albany, NY between 2005 and 2008. Participants were interviewed, completed surveys, and medical charts were abstracted. Physical activity, fluid intake, and smoking history at baseline were compared with changes in estimated glomerular filtration rate (eGFR) (every 6 months up to 1 year) using bivariate and multivariate regression analysis, while controlling for sociodemographic and clinical transplant variables. Multivariate analyses revealed that greater physical activity was significantly ($P < 0.05$) associated with improvement in GFR at 6 months; while greater physical activity, absence of smoking history, and nonwhite ethnicity were significant ($P < 0.05$) predictors of improvement in GFR at 12 months. These results suggest that increasing physical activity levels in kidney recipients may be an effective behavioral measure to help ensure graft functioning. Our findings suggest the need for a randomized controlled trial of exercise, fluid intake, and smoking history on GFR beyond 12 months.

Introduction

Despite recent improvements in 1-year renal transplant survival, long-term graft survival and function remain inadequate [1,2]. As 1-year estimated glomerular filtration (eGFR) rate predicts long-term graft function [3], maximizing graft function in the short-term period (6–12 months) is critical to ensuring long-term success. Examining factors contributing to short-term graft function is therefore important for identifying ways to maximize long-term graft function.

Most studies of factors contributing to renal transplant function examine immunological and nonimmunological factors related to the donor, recipient, and post-transplant events [1,4,5]. However, relatively little attention has focused on how patients' self-care behaviors affect kidney graft function. Self-care refers to 'the range of behavior[s] undertaken by individuals to promote or restore their health,' [6] including adherence to medication, exercise and dietary recommendations, monitoring symptoms, maintaining physical function, executing medical regimens, and making decisions about seeking care [7]. Self-care is vital for patients with chronic illnesses, as they must undertake daily monitoring and adhere to treatment regimens [8,9]. The adverse effects on graft function of medication nonadherence [10,11] are well documented, as is cigarette smoking [12,13]. Although transplant clinicians advise kidney recipients to engage in physical activity and to drink enough fluid to stay adequately hydrated, e.g., approximately 2–3 l of fluid per day, the impact of these self-care practices on graft function over time remains to be examined.

The limited available evidence suggests the relationships between physical activity and hydration and graft function. One study of 22 pediatric and adolescent kidney transplant recipients found that impaired maximum oxygen consumption, often associated with sedentary behavior, is associated with higher serum creatinine levels through an exercise testing protocol [14]. It has been demonstrated that a DanJeon breathing exercise program significantly reduces kidney recipients' serum creatinine levels [15]. Others have called for examining the relationship between physical activity and transplant outcomes [16]. Other research shows that pre-transplant inactivity predicts poor post-transplant graft and patient survival [17,18]. Although there is insufficient evidence of the importance of ample fluid intake in patients with chronic kidney disease [19], the case for or against fluid intake in kidney transplant recipients has been neither discounted in the literature nor empirically tested. In anecdotal findings of adult kidney recipients' barriers to fluid intake, patients recounted that clinicians attributed dehydration as a cause of their elevated creatinine levels [20].

While self-care encompasses a broad array of behaviors, attitudes, and emotions, we focus primarily on health promoting self-care practices relating to physical activity and fluid intake, because transplant professionals promote engagement in these behaviors as essential for self-care management for the kidney transplant. Smoking was also examined because this behavior can adversely affect transplant outcomes, although it does not rule out patients from being placed on the waiting list. The aim of the present study was to examine whether physical activity, adherence to fluid intake recommendations, and smoking history are related to kidney graft function over time, in a group of adult kidney recipients, followed up over 12 months.

Patients and methods

All adult kidney transplant recipients were recruited prospectively from Loyola University Medical Center (LUMC) in Maywood, IL (July 2004 – May 2006) and from Albany Medical Center (AMC) in Albany, NY (September 2006 – March 2008). Kidney transplant recipients were eligible for participation if they were 18 years and older, spoke English, received a kidney transplant within the previous 6 weeks, and were currently taking immunosuppressants.

Interview

We conducted semi-structured interviews with kidney recipients on average 2 months post-transplant. This study employed a prospective, longitudinal study design. Assessment periods occurred at 2 (baseline), 6, and 12 months post-transplant. This design enabled us to include a broad range of patients with self-care practices and health statuses early post-transplant. Semi-structured interviews were conducted in person or over the telephone. Topics covered in the interview, as they pertain to this paper, included: (a) levels of self-care practice for exercising, drinking fluids, and smoking history, and (b) demographics and medical information. Interviews were tape recorded, lasted on average 2 h, and transcribed verbatim. Respondents were compensated $20 for their time. Institutional Review Board approval was obtained from Loyola University Medical Center and Albany Medical Center. Study participants provided written informed consent.

Medical record review

Medical charts were abstracted for clinical information relating to kidney graft function (e.g., serum creatinine [Scr] levels). The baseline Scr level was obtained at the first indication of it reaching a plateau following transplantation. Thereafter, medical records were abstracted on the dates closest to the 6-, and 12-month post-transplant time points for each patient.

Measures

Physical activity level was assessed using the Physical Activity Scale for the Elderly (PASE) [21]. The PASE was designed to assess physical activity in epidemiologic studies of people aged 65 years and older, and has been validated in younger patients on hemodialysis (mean age 52 ± 16 years) [22]. This instrument includes more activities at the lower end of the activity spectrum, which are expected in the end-stage renal disease

(ESRD) population [23]. The PASE is a self-administered, 21-item instrument that uses four-point Likert scales to ask about participating in household activities, occupational activities, and leisure time activities over the past 7-day period. PASE scores can range from 0 to 795 with higher values representing the completion of more physical activity. Internal consistency of all items was $\alpha = 0.69$, and test–retest reliability coefficient was 0.75 [23,24]. Regular physical activity is defined here as 30 min of physical activity three or more times per week (90 min). Although PASE scores can be categorized into 'sedentary' (0–99), 'moderate' (100–150), and 'active' (151+) physical activity levels, which are comparable to recommended levels [25], we analyzed PASE as a dichotomous (sedentary versus moderate + active) categorical variable because of limited variation in the sample.

Fluid intake was assessed by asking patients how many ounces or liters of fluid they ingested daily. Fluid adherence was determined if patients reported drinking the recommended three or more liters of fluid daily. Fluid intake was analyzed as a dichotomous variable (adherent versus nonadherent).

Smoking history was assessed by asking patients if they currently smoked or used to smoke, but have since quit. Patients who responded affirmatively to either question were categorized as having smoked, and were dichotomized into a single smoking history variable (have smoked versus never smoked). We dichotomized this variable in this fashion to account for the residual effects of smoking in the past on health.

Health status, a single global item assessment, was used to assess health status: 'How would you rate your health compared to people your age with a transplant?' with 'excellent,' 'very good,' 'good,' 'fair,' and 'poor' as eligible responses.

Demographic characteristics assessed included age, gender, education, race/ethnicity (white versus non-white), income, employment status, and primary insurer (private versus Medicare or Medicaid).

Geographic characteristic assessed was patients' estimated travel time to the transplant center (0–30 min versus 31–60 min versus 61 + min).

Clinical characteristics assessed were cause of ESRD (diabetes, hypertension, glomerulonephritis, polycystic kidney disease, other), source of donor kidney (living versus deceased donor), and number of transplants (one versus two or more transplants).

Graft function was assessed using serum creatinine levels to estimate glomerular filtration rates (GFR) using the Modification of Diet in Renal Diseases study equation, as recommended by the National Kidney Foundation's Kidney Disease Outcomes Quality Initiative clinical practice guidelines [26,27]. GFR was based on creatinine level, gender, age, and race (African American versus not African American). The outcome variable is mean change in GFR, which is defined as the difference between Baseline GFR and the follow-up GFR value (at 6- or 12-months). The stages of chronic kidney disease in (GFR ml/min/1.73 m^2 (kidney function) are 1 (≥90), 2 (60–89), 3 (30–59), 4 (15–29), and 5 (<15 or dialysis).

Statistical analysis

Simple analyses of physical activity, fluid intake adherence, demographic, and clinical predictors of mean change in GFR between baseline and each follow-up period were based on the comparison of means for categorical predictors. One-way analysis of variance (ANOVA) was used to assess whether there was a significant mean difference among the levels of predictors (*t*-tests for dichotomous independent variables). We controlled for baseline GFR as covariate to reflect change relative to the baseline variables in the models. Spearman correlation coefficients and associated *P* values were calculated for continuous predictors of mean change in GFR.

Multivariate regression models were used to examine the impact of a set of covariates on the mean change in GFR. Independent variables included self-care practices (physical activity, fluid intake adherence, smoking history), demographic (age, gender, race/ethnicity, marital status), socioeconomic (income, education), geographic (travel time to transplant center), clinical (cause of ESRD, source of donor kidney, number of transplants). Dependent variables included mean change in GFR between baseline and 6 months, and baseline and 12 months. Linear regression was used for the analysis of mean change in GFR. Selection of independent variables was done in three stages. The first stage involved bivariate analyses using $P < 0.10$ criteria and conceptual justification. Variables significant at $P < 0.10$ level in bivariate analyses were included in the second phase of bivariate analyses, which examined the relationship between each independent variable alone, and mean change in GFR while controlling for baseline GFR. Variables significant at $P < 0.10$ level in the second phase of bivariate analyses were included in the multivariate analyses. The purpose of this analysis was to assess the predictors of GFR at 6- and 12-months (with adjustment for GFR at baseline). Multivariate analyses examined the combined variables that were $P < 0.10$ in the second phase of bivariate analyses. Respondents who did not answer a specific question were excluded from analysis. All tests were two-tailed and $P < 0.05$ was considered statistically significant. All statistical analyses were performed using SPSS 15.0 (SPSS, Inc., Chicago, IL, USA).

Results

Patient population

A total of 90 out of 158 (57%) eligible patients participated. Twenty-two per cent (n = 35) refused to participate because of slow recovery from the operation, feeling overwhelmed with the transplant, time commitments, burden of paperwork involved or disinterest; 4% were undecided (n = 7); and 16% (n = 26) gave oral consent, but did not provide written consent or were unable to be reached for an interview. Two participants had incomplete data and were therefore excluded from analysis resulting in a sample of 88. Study participant characteristics are summarized in Table 1. A majority of patients were European American (68%; 17% African American, 8% Hispanic, and 7% other). Ages ranged from 18 to 74, with a mean of 48 years. As shown in Table 1, this sample had a low level of self-reported physical activity. There were no differences in known demographics or GFR levels between those who participated and those who refused to participate in the study or between transplant centers. The mean GFR values for the total sample over time were: 53 ml/min/1.73 m^2 at baseline, 53 ml/min/1.73 m^2 at 6 months, and 52 ml/min/1.73 m^2 at 12 months. There were equivalent proportions of patients who had stages 1–3 versus 4–5 across baseline, 6-, and 12-month periods (97% vs. 3%; 97% vs. 3%; and 95% vs. 5%, respectively).

Bivariate analyses controlling for baseline GFR

Table 2a presents the findings of bivariate analyses when controlling for baseline GFR. Note that based on the initial stage of bivariate analyses, age and other demographic variables were not significantly associated with graft function and therefore were not included in the second stage of bivariate analyses. When controlling for baseline GFR, we found that, individually, greater physical activity ($P < 0.01$), adherence to fluid intake ($P < 0.05$) and male gender ($P < 0.05$) were statistically significant predictors of better graft function at 6 months (Table 2a). Being nonwhite ($P < 0.10$) approached statistical significance with better graft function at 6 months. Similarly, we found that individually, adherence to fluid intake ($P < 0.05$), the absence of a history of smoking ($P < 0.01$), male gender ($P < 0.05$), and being nonwhite ($P < 0.05$) were statistically significant predictors of better graft function at 12 months ($P < 0.05$) (Table 2b). Greater physical activity, not having glomerulonephritis as the cause of ESRD, and having received a fewer number of transplants approached statistical significance with better graft function at 12 months ($P \leq 0.10$). Analyses between living and deceased donor recipients were not significantly related to any self-care practices or to any

Table 1. Characteristics of study participants (n = 88).

Variable	*n*	%
Demographics		
Age (years), mean, (SD) (range)	48 (12)	18–74
18–48	45	51
49–74	43	49
Gender		
Female	37	42
Male	51	58
Ethnicity/Race		
White	61	69
African American	15	17
Hispanic/Other	12	14
Education (years), mean, (SD), (range)	14 (3)	6–27
< and = High School	33	38
High School Grad/GED	54	61
Gross household income*		
<$14 999–$29 999	22	25
$30 000–$59 999	24	27
$60 000+	35	40
Primary insurer*		
Private insurance	46	52
Medicare/Medicaid	40	46
Travel time to transplant center (minutes), mean, (SD), (range)	61 (55)	5–300
0–30	31	35
31–60 min	32	36
61+ min	24	27
Health status		
Cause of ESRD		
Diabetes	8	9
Hypertension	21	24
Glomerulonephritis	18	21
Polycystic kidney disease	19	22
Other	22	25
Organ donor source		
Deceased donor	48	55
Living donor	40	46
Number of transplants		
1	70	80
2+	18	21
Self-rated health		
Excellent	13	15
Very good	31	35
Good	32	36
Fair	10	11
Poor	1	1
Fluid intake*		
Adherent	30	34
Nonadherent	56	64
PASE*		
Sedentary	66	75
Moderate, but not enough	11	13
Regular physical activity	10	11
Smoke		
Ever	31	35
Never	57	65

ESRD, end-stage renal disease; PASE, Physical Activity Scale for the Elderly.
*Total n does not add up to 88 because participant(s) did not know or disclose information.

predictor variables, and was not associated with 6- and 12-month outcomes.

Multivariate analyses

We examined the associations between the self-care, demographic and clinical variables and mean change in GFR using multivariate analyses across 6 and 12 months (see Table 3a, b). The total explained variation in the models for 6 and 12 months was 36% and 43%, respectively. When combining all significant variables in the model, we found that greater physical activity was a significant predictor of improvement in GFR at 6 months ($P < 0.05$). The mean difference in GFR of patients who were moderately or regularly physically active was approximately eight points higher than the score of patients who were sedentary. Figure 1 illustrates the relationship between physical activity and GFR using analysis of covariance to generate covariate-adjusted values for change in GFR by level of physical activity. From a common baseline GFR (53), the estimated difference at 6 months represents a projected increase in the GFR of active patients (to 59.1) and a decline in inactive patients (to 51.2) based on the linear regression model.

At 12 months, greater physical activity, the absence of smoking history and being nonwhite were significant predictors of improvement in GFR ($P < 0.05$). Figure 1 shows that the magnitude of the difference in GFR associated with physical activity at 6 months was still evident at 12 months. The multivariate analysis also revealed that change in GFR at 12 months was seven points higher for

Table 2. Bivariate analyses for each individual predictor and mean change in graft function.

Predictor variables	β	95% CI
(a) At 6 months post-transplant controlling for GFR at baseline		
GFR at baseline	–	–
Physical activity (1 = moderate/active, 0 = sedentary)	7.922***	1.870, 13.973
Fluid intake (1 = adherent, 0 = nonadherent)	5.938**	0.362, 11.514
Smoking history (1 = smoked; 0 = never smoked)	−3.543	−9.076, 1.991
Gender (1 = female; 2 = male)	6.188**	0.932, 11.444
Race/Ethnicity (1 = white; 0 = nonwhite)	−4.889*	−10.57, 0.793
Primary insurance (1 = private; 2 = public)	−1.692	−7.167, 3.782
Travel time 3 cats 31–60 min†	−4.517	−10.731, 1.697
Travel time 3 Cats 60+ min	1.646	−5.059, 8.351
Cause of ESRD – Hypertension‡	3.769	−6.370, 13.908
Cause of ESRD – Glomerulonephritis	−5.801	−16.214, 4.612
Cause of ESRD – PKD	−2.863	−13.176, 7.451
Cause of ESRD – Other	0.578	−9.496, 10.652
Number of transplants (1 = 1, 2 = 2 or more transplants)	0.009	−6.915, 6.934
(b) At 12 months post-transplant controlling for GFR at baseline		
GFR at baseline	–	–
Physical activity (1 = moderate/active, 0 = sedentary)	7.283*	−0.350, 14.917
Fluid intake (1 = adherent, 0 = nonadherent)	7.278**	0.303, 14.253
Smoking history (1 = smoked; 0 = never smoked)	−9.278***	−16.006, −2.55
Gender (1 = female; 2 = male)	7.056**	0.575, 13.537
Race/Ethnicity (1 = white; 0 = nonwhite)	−7.648**	−14.409, −0.888
Primary insurance (1 = private; 2 = public)	−1.744	−8.422, 4.933
Travel time 3 Cats 31–60 min†	−3.958	−11.686, 3.769
Travel time 3 Cats 60+ min	−0.179	−8.601, 8.244
Cause of ESRD Hypertension‡	4.560	−7.896, 17.016
Cause of ESRD Glomerulonephritis	−10.989*	−23.939, 1.962
Cause of ESRD PKD	−8.825	−21.677, 4.026
Cause of ESRD Other	−3.251	−15.644, 9.141
Number of transplants (1 = 1, 2 = 2 or more transplants)	−7.249*	−15.604, 1.107

ESRD, end-stage renal disease; GFR, glomerular filtration rate.
†Referent group = 0–30 min.
‡Referent group = diabetes.
*$P < 0.10$, **$P < 0.05$, ***$P < 0.01$.

Table 3. Multivariate analyses.

Variable	β	95% CI
(a) At 6 months		
GFR at baseline	−0.307***	−0.448, −0.167
Physical activity (1 = moderate/active, 0 = sedentary)	7.840**	1.721, 13.96
Fluid intake (1 = adherent, 0 = nonadherent)	3.536	−2.135, 9.206
Gender (1 = female; 2 = male)	4.101	−1.394, 9.597
Race/Ethnicity (1 = white; 0 = nonwhite)	−4.642	−10.188, 0.904
(b) At 12 months		
GFR at baseline	−0.349***	−0.533, −0.164
Physical activity (1 = moderate/active, 0 = sedentary)	7.438**	−0.106, 14.981
Fluid intake (1 = adherent, 0 = nonadherent)	3.824	−3.33, 10.978
Smoking history (1 = smoked; 0 = never smoked)	−7.223**	−14.19, −0.257
Gender (1 = female; 2 = male)	1.759	−5.138, 8.656
Race/Ethnicity (1 = white; 0 = nonwhite)	−6.745**	−13.456, −0.034
Number of transplants (1 = 1, 2 = 2 or more transplants)	−7.085*	−15.315, 1.144

GFR, glomerular filtration rate.
*$P < 0.10$, **$P < 0.05$, ***$P < 0.01$.

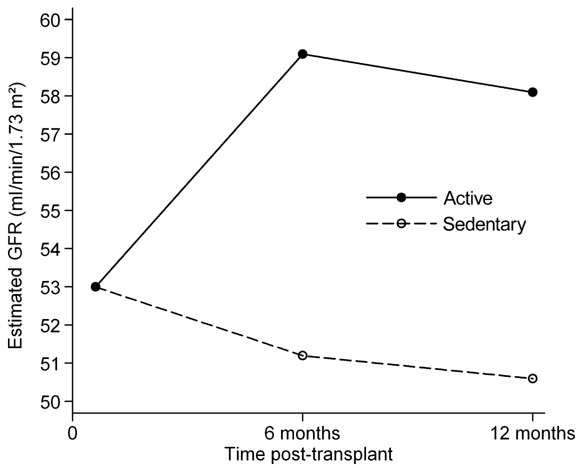

Figure 1 Covariance-adjusted GFR levels at 6 and 12 months, by level of physical activity reported at baseline. Six-month GFR is adjusted for baseline GFR, adherence to recommended fluid intake, gender, and race/ethnicity; 12-month GFR is adjusted for baseline GFR, adherence to recommended fluid intake, gender, race/ethnicity, smoking, and number of transplants. Baseline GFR is calculated from the plateau; average time to plateau ranged from 2 to 4 weeks post-transplant.

patients who never smoked compared with current or past smokers. A similar advantage in GFR change at 12 months was observed for nonwhite patients compared to whites.

Discussion

This longitudinal study is the first to examine the relationship between patient self-care practices and renal graft function over time. The results of this analysis demonstrate that greater physical activity, and a history of non-smoking are associated with improved graft function over a 1-year period. As this is a relatively brief time frame of analysis, it is unknown whether self-care practices continue to be associated with graft function over the long-term. Nonetheless, given that graft function in the early post-transplant period predicts long-term function [3], it is essential that efforts are taken to improve graft function in the short-term. As a modifiable factor that is related to improved transplant outcomes, self-care practice of physical activity deserves careful attention.

The relationship between physical activity and graft outcomes makes sense in light of other related research on the impact of physical activity on health. Physical activity leads to improved cardiovascular function, which probably improves perfusion and oxygen delivery to the kidney graft. Physical activity may also delay development of atherosclerosis, which is the primary cause of death among kidney transplant recipients [28,29]. Despite the beneficial effects of physical activity, 75% of kidney recipients do not exercise adequately according to levels recommended by the Surgeon General (3 times per week) [25]. Although kidney recipients engage in more physical activity after transplant compared with when on maintenance dialysis [30], our findings are consistent with national trends that 22% of people aged 65 years and over engage in moderate-to-active physical activity [31,32]. It may also be that patients adherent in one self-care practice are more likely to be adherent with other practices. Accordingly, engaging in regular physical activity or having a high fluid intake may be associated with medication compliance; thus, patients who engage in such practices would have better graft function.

We found that fluid adherence was related to better graft function in bivariate analysis, but this relationship did not persist in multivariate analysis. It may be that fluid intake was related to physical activity in that those who do well in one activity also do well in another (although multicollinearity was not discovered between these variables). A larger sample may be able to tease apart this relationship and demonstrate a multivariate relationship between fluid intake and graft function.

We found that females experienced worse graft function than males. Other research confirms this finding, attributing the pattern to sensitization from pregnancy [33]. We also found evidence that kidney recipients with a self-identified ethnic/racial group 'Other' (i.e., Hispanic or Middle Eastern) had better improvement in graft function than whites or African Americans at 1-year post-transplant. Other research corroborates our findings by reporting better or equivalent graft outcomes for Hispanics than for non-Hispanic whites, although this remains controversial [34–36]. This finding is counter-intuitive given research documenting worse graft outcomes for African Americans [37]. However, the literature is inconsistent as to when disparities in transplant outcomes emerge in the long-term: either at 1 year [38–40] or 3 years [41].

Clinical recommendations and future research

We recommend that transplant health care providers and/or nephrologists refer patients to appropriate exercise programs. For example, a walking program would improve health but not strain individuals [42]. Given that exercise training in kidney transplant recipients is feasible and results in increased exercise capacity and muscular structure and function [43,44], establishing rehabilitation centers in transplant programs is needed [43]. Although our findings are suggestive of the influence of exercise, fluid intake, and smoking history on GFR, the need for a randomized controlled trial is evident. Examining self-care among a more diverse sample may also illuminate whether racial/ethnic or socioeconomic differences in self-care practices emerge. As we found some differences between the two time frames, future research should explore appropriate time frames for follow-up.

Limitations

The present study has several limitations. First, the recruitment attrition rate of 43% may have resulted in a biased sample. It is possible that recruitment attrition may be related to poor health, which may be correlated with poorer adherence to recommended self-care behaviors. This is indicated by the fact that 22% of patients refused participation because of slow recovery and feeling overwhelmed by the transplant, among other reasons. Generalizability of our findings should be cautioned. Given that the sample was highly educated, the findings may not necessarily represent the full range of demographics among kidney recipients. It may also be that those who refused to participate were sicker and therefore less able to engage in physical activity. We looked at the prevalence of self-care behaviors and recognize that the exposure to risk factors is also a parameter of health. Some support for external validity derives from the fact that while this was a multisite study, no significant differences in self-care practices or mean change in GFR levels were found across time points across sites. The reduction in sample size over time was because of the longitudinal recruitment design rather than participant attrition. List deletion of participants because of missing data was minimal ($n = 2$ people). Similarly, there was a small number of participants who died or moved away ($n = 3$), so we did not analyze the subgroup. For reasons of design considerations, the only clinical variable that was measured across the time points was mean change in GFR. An ideal analytic tool for this longitudinal study is to employ techniques based on either generalized estimating equations or a mixed-effects models framework which have the capability to inform practitioners about change over time while calculating the standard errors accurately. Further, because of attrition, we were unable to analyze how change in self-care is associated with change in graft function. We also assessed self-care and graft function early post-transplant, which may have both advantages and disadvantages for analyzing self-care practices. Patients early post-transplant are likely to be more adherent to clinicians' physical activity and fluid intake recommendations given their high excitement level, compared with later post-transplant. This is supported by research demonstrating that medication adherence declines over time [45]. However, patients may not have integrated self-care practices into their daily routines. However, additional analyses of data from this study found that patients establish their self-care routines early post-transplant [20,46]. Further, findings were based on patients' self-report and no independent validation of patients' self-care practices was conducted. Patients' self-reports of fluid intake are likely to be accurate because for the first 2 weeks post-transplant they are required to track the milliliters of fluid they drink and void. Response bias arising out of social desirability of positive health practices cannot be ruled out. However, interview techniques were employed to minimize social desirability bias, including trained social scientists who were not affiliated with either transplant center and establishing rapport with patients who, in turn, provided open responses [47]. Moreover, despite the fact that transplant clinicians routinely promote fluid intake among kidney transplant recipients, there is insufficient evidence for such clinical recommendations. The amount of fluid intake clinicians recommend per day may vary depending on the season of the year and likely by transplant center. Lastly, eGFR is the best and most clinically relevant and readily available measure of kidney function; however, MDRD GFR underestimates true GFR [48].

In conclusion, our results show that physical activity is significantly associated with graft function up to 12 months after renal transplantation. These findings suggest that increasing physical activity levels in kidney recipients may be an effective behavioral measure to help ensure graft functioning.

Authorship

EJG: Designed research/study, performed research/study, collected data, analyzed data, wrote the paper. TRP, ARS and LAS: Designed research/study, wrote the paper. MPG: Wrote the paper. RY: Wrote the paper, analyzed data. DC: Provided access to research site, wrote the paper. DS: Analyzed data, wrote the paper.

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