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Characterization of Body Composition and Fat Mass Distribution 1 Year After Kidney Transplantation

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Abstract

Purpose: In some recipients, significant weight gain occurs after kidney transplantation. Weight gain is associated with poor outcomes, particularly increased cardiovascular risk. In this study, we characterized changes in body mass index and body fat mass and compared them based on gender and race.

Methods: Fifty-two kidney transplant recipients (aged 18 years old, 50% men, 58% African American) were enrolled into a prospective study. Body mass index and body fat mass were measured at baseline and 12 months posttransplant. Body fat mass was determined by dual-energy X-ray absorptiometry.

Results: The mean increase in body weight was 3.7kg at 12 months; 36.5% (n=19) gained at least 10% of their baseline body weight. Body mass index, percentage of total body fat, and trunk fat were significantly increased. In subgroups, women and African American showed significant increases in body mass index and body fat measures. More participants were classified as obese based on total body fat compared to body mass index. Calories from fat were significantly increased at 12 months and associated with increased body mass index, total body fat, and trunk fat. Days of physical activity were significantly increased.

Conclusion: Both body mass index and total body fat mass were significantly increased at 12 months following kidney transplantation, especially for women and African Americans. Importantly, more participants were classified as obese based on total body fat compared to body mass index. Relevant nutrition and physical intervention should be provided, and both body mass index and body fat mass should be evaluated when monitoring weight gain.

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Declaration of Conflicting Interests

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Keywords

kidney transplant; obesity; weight gain; body fat mass; BMI

Introduction

Following the trend in the general population, the prevalence of obesity in kidney transplant recipients has increased over the past decades. Up to 60% of these patients are now classified as overweight or obese at the time of transplant, followed by a mean weight gain between 5 and 10 kg within the first year posttransplant.^{1,2} This rapid and substantial increase in body weight posttransplant is associated with poor long-term graft success and development of comorbid conditions including hypertension and diabetes.^{3,4}

Body mass index (BMI) is widely used as a clinical measure of overweight/obesity because it is an inexpensive and easy method to employ. It has been supported by the World Health Organization (WHO)⁵ and the Centers for Disease Control and Prevention (CDC).⁶ However, some clinical studies have demonstrated that misclassification of obesity was generally higher with the BMI-based prediction compared to using percentage of body fat (BF).⁷ It was also reported that BMI cutoff values fail to identify half of the people with excess BF percentage.⁸ WHO and CDC emphasize clinical limitations of BMI because it does not reflect other factors including age and gender. More importantly, it provides no information about body composition or regional adiposity, which is associated with the risk of cardiovascular diseases.^{8,9}

Body fat, especially visceral fat stored within the abdominal cavity, is considered to be the primary mediator of adverse effects, particularly increased cardiovascular risk, associated with obesity.⁹ Excess visceral fat is accompanied by elevated triglycerides, reduced high-density lipoprotein cholesterol, elevated blood pressure, and/or elevated fasting plasma glucose. In addition, visceral fat is also capable of secreting large quantities of pro-inflammatory cytokines including tumor necrosis factor α , interleukin 1, and interleukin 6, which have been shown to be associated with cardiovascular diseases.¹⁰ In order to measure BF composition including visceral fat, dual-energy X-ray absorptiometry (DXA) is commonly used due to its advantage of high precision, low X-ray exposure, and short scanning time. It measures fat mass, nonbone lean mass, and bone mineral content; therefore, BF distribution and regional bone mineral density can be determined. In the kidney transplant population, studies of body composition have primarily focused upon bone mineral changes and the association between fat mass gain and steroid use.^{11,12} Thus, we have limited knowledge of BF mass changes following kidney transplant and associated factors other than steroids. Given the important effect of increased visceral fat on outcomes of transplantation, a more complete characterization of changes in body mass composition and distribution may provide direct clinical value.

The purpose of this study was to compare and evaluate changes in BF distribution and BMI between time of transplant and 12 months posttransplant in kidney transplant recipients. In addition, we determined whether changes in BF distribution and BMI were associated with factors such as gender, race, dietary intake, and physical activity.

Patients and Methods

This study is a secondary analysis of a single-center prospective study that followed kidney transplant recipients in a Mid-South Transplant Institute. De-identified data were obtained from the parent study, which considered the association of genetic and environmental factors on weight gain and obesity after kidney transplantation.^{13,14}

The study included single-organ kidney transplant recipients 18 years or older who had matching DXA data at the time of transplantation (baseline) and 12 months follow-up (n = 52). Institutional review board approval was obtained, and all participants were consented prior to or at the time of transplantation. Participants receiving steroid therapy prior to transplantation were excluded to control for the effect of prior steroid use on weight gain, BF mass composition, and distribution. Immunosuppressant therapies and medications for treatment of comorbid conditions were administered according to a standardized center-specific protocol, which was previously described.¹⁴

Clinical data were obtained from 2 time points, baseline and 12 months posttransplant. Body mass index (kg/m^2) was categorized according to the WHO classification,⁵ such as underweight (<18.5), normal weight ($18.5\text{--}24.9$), overweight ($25.0\text{--}29.9$), and obese (≥ 30.0). Hypertension was determined by either blood pressure $>140/90$ mmHg or the use of antihypertensive medication. Diabetes was determined during a chart review by a diagnosis of diabetes. Hyperlipidemia was determined by either a diagnosis of hyperlipidemia or a prescription for a cholesterol-lowering drug.

Body composition from DXA was obtained with a standardized protocol on the Discovery A DXA System version 8.3 (Hologic, Bedford, Massachusetts) at baseline and 12 months posttransplant. Measures included total body mass (kg), total BF mass (kg), percentage of total BF (%BF), trunk fat (TF) mass, percentage of TF (%TF), and total lean body mass (kg). The truncal region in DXA includes fat deposits other than those in the intra-abdominal or visceral cavity, including sub-cutaneous and intermuscular fat throughout the trunk region, in addition to epicardial and pelvic deposits. We considered TF as an appropriate proxy for intra-abdominal fat based on the previous report showing highly significant correlation between TF and magnetic resonance image-derived total visceral adipose tissue.¹⁵ Participants whose %BF was over 25 (men) or 30 (women) were categorized as obese.⁸ Total body mass from DXA was used for body weight (kg) and BMI determination.

Methods used for obtaining nutritional and physical activity data have been described previously.¹⁴ Briefly, 24-hour nutritional intake for 3 days at each time point was obtained from participants through telephone interviews by experienced research assistants. The 7-Day Physical Activity Recall was used to assess physical activity. Number of days per week of 30 minutes or more of moderate or harder physical activity, that is greater than 3 metabolic equivalents, were determined and used for analysis.

Paired t tests, χ^2 or Fisher exact tests, and analysis of variance were used to identify significant differences. Estimated Pearson product-moment correlation coefficients were used to identify significant associations among continuous variables. McNemar test was used to compare and evaluate the concordance of 2 methods to determine obesity category.

(BMI vs %BF from DXA). Data were analyzed using SAS version 9.3 (SAS Institute Inc, Chapel Hill, North Carolina) and IBM SPSS Statistics version 22.0 (Armonk, New York).

Results

Demographic characteristics of the participants ($n = 52$) are described in Table 1. Participants averaged 53 years of age at the time of transplant; 50% were male and 58% were African American (AA). Most (80.8%) obtained an organ from a deceased donor. A standard center-specific immunosuppressant protocol was followed for all recipients.

The majority of participants gained weight at 12 months ($n = 34$, 65.4%). The mean increase in body weight was 3.7 kg at 12 months, and 19 (36.5%) participants gained at least 10% of their baseline body weight. Both weight and BMI significantly increased for the total group (Table 2). Subgroup analysis based on either gender or race showed that women and AAs had significant increases in weight and BMI; BMI was increased from 26.2 to 27.8 kg/m² in women ($n = 26$, $P = .016$) and 27.7 to 29.6 kg/m² in AAs ($n = 30$, $P = .001$) in 12 months. Although both men and Caucasian subgroups gain weight and had an increase in BMI, these did not reach significance. To determine whether a gender by race interaction was present, we examined these subgroups independently. African American women ($n = 15$) was the only subgroup that had a significant increase in body weight (70.0–77.9 kg, $P = .004$) and BMI (26.3–29.3 kg/m², $P < .001$).

Changes in body composition were also described for the total group and subgroups based on either gender or race (Table 2). Both %BF and %TF were significantly increased in the total group and each subgroup by gender. Total lean body mass was slightly decreased in men and increased in women participants at 12 months, however, neither was significant. In subgroups by race, all BF composition measures except total lean body mass were significantly increased for AAs at baseline and 12 months. In contrast, Caucasians showed no difference at the 2 time points. Among women participants, AA women ($n = 15$) had significant increases in all body composition measures except total lean body mass as compared to Caucasians women ($n = 11$) who had no significant changes. In contrast, both AA men ($n = 15$) and Caucasian men ($n = 11$) had no significant changes in all body composition measures (data not shown).

When comparing BMI and %BF as classifications for obesity (Figure 1), 17 participants (32.7%) were classified as obese at baseline and 21 (40.4%) at 12 months using BMI. In contrast, using %BF, 38 (73.1%) participants were classified as obese at baseline and 39 (75.0%) at 12 months. More participants were obese at both baseline and 12 months based on the DXA-derived measures of %BF compared to BMI. In all subgroups, the same trend was observed at both time points (data are not shown). Most of the obese participants who were classified as obese by %BF but not by BMI were women. The number of women classified as obese by BMI versus %BF was 5 versus 22 at baseline and 8 versus 23 at 12 months, respectively.

Changes in dietary intake and physical activity from baseline to 12 months are described at Table 3. Total calorie intake was not significantly changed. The amount of fat, protein, and

carbohydrate intake were also similar between the 2 time points. Meanwhile, calories from fat (%) were significantly increased at 12 months. Changes in calories from fat (%) from baseline to 12 months were associated with increases in BMI ($r = 0.381$; $P = .005$) and body composition changes including BF ($r = 0.318$; $P = .022$) and TF ($r = 0.343$; $P = .013$). However, the mean change in daily caloric intake from baseline to 12 months was not associated with changes in BMI and body composition.

Days of physical activity significantly increased at 12 months for the total group ($P = .018$). At baseline, participants who reported 0 day per week of moderate or harder activity was 50% ($n = 26$), whereas at 12 months, this decreased to 21% ($n = 11$), and 24 (46%) participants reported a minimum of 3 days per week of moderate or harder activity. However, the average energy expenditure was not significantly changed.

Discussion

In this study, we characterized changes in BMI and BF composition by DXA during the first year after kidney transplantation. Body weight, BMI, and measures of total and trunk BF mass, but not lean body mass, were significantly increased at 12 months posttransplant. Over 65% of participants gained weight at 12 months following transplant, with 37% gaining at least 10% of their baseline weight. Nutrition intake data showed that calories from fat (%) were significantly increased, and this increase was correlated with increased BMI, BF, and TF. Days of activity were increased at 12 months posttransplant, although the average energy expenditure was not significantly changed.

Our finding showing that %BF was significantly increased following transplantation concurs with others.^{16,17} Most importantly, we also found that TF was significantly increased in the total group. It is reported that TF measured from DXA has a high correlation with visceral adipose tissue.¹⁵ Generally, visceral adipose tissue accumulation contributes to subcutaneous adipose tissue dysfunction, which is closely related to cardiovascular risk factors.⁹ In kidney transplant recipients, increased posttransplant visceral fat also has been found to be associated with impaired glucose metabolism and new-onset diabetes after transplant,^{18,19} although few studies have been conducted with %BF from DXA. von Düring et al. reported that visceral fat is better related to impaired glucose metabolism than BMI after kidney transplantation.¹⁹ They showed significant correlation between visceral adipose tissue and fasting and 2-hour glucose concentration. However, no correlation was found with BMI.

In addition, reports have shown a discordance between BMI and %BF in identifying obesity after transplantation,^{20,21} with %BF identifying more recipients as obese than BMI does. In our study, we found more than 30% of the participants as obese at both time points when classified according to %BF by DXA, which was much higher than the number classified as obese by BMI. This trend was noted regardless of race or gender. Interestingly, this discordance was most apparent for our women participants. Body mass index may have a low sensitivity and/or specificity for certain groups of individuals because it fails to distinguish components of body mass and to differentiate the regional distributions of fat.²² Recently, instead of BMI, waist circumferences and waist-hip ratio were used to predict obesity-related health risk, since these are highly correlated with abdominal fat.^{23,24}

However, obtaining waist–hip ratios can be challenging in dialysis patients due to fluid buildup and in recent transplant recipients due to swelling and other postsurgery issues. Therefore, these measures were not used in this study.

The observation that body weight, BMI, and BF distributions (%BF and %TF) significantly increase by 12 months posttransplant for AAs but not Caucasians is particularly interesting. It is known that AAs have greater bone mineral density and lean muscle mass than do Caucasians^{25,26}; therefore, AAs would have less visceral fat mass than Caucasians.²⁷ However, in kidney transplant recipients, it has been reported that AAs gain more weight than Caucasians,^{2,28} which is congruent with our current study. In addition, we found only women to have significant increases in weight and BMI by 12 months post-transplant compared to male participants, which is consistent with others.²⁹ This observation carries with its clinical importance for the monitoring and care of women, in particular, following kidney transplantation. To our knowledge, this is the first time the racial differences in BF distribution after kidney transplant have been reported. Most importantly, we found that AA women were the group most at risk for increases in BF mass. By using DXA, we identified both racial and gender disparities in the %BF increase following transplantation. The mechanism of racial and gender differences in increased BF posttransplant has not been elucidated yet. Genetic and environmental factors might play a role, which could provide opportunities for future study.

Due to the endocrine and metabolic effects of steroid therapy, many transplant recipients have experienced weight gain as a side effect.³⁰ With early corticosteroid withdrawal (7 days), it should follow that cardiovascular risk including weight gain would be significantly reduced.³¹ However, studies have indicated that steroid use is not the primary factor responsible for weight gain after kidney transplant.^{3,30,32} In our study, all recipients were on a standardized posttransplant protocol that tapered the dose of prednisone to approximately 5 mg/day by 12 months posttransplant. Therefore, the effect of steroid dose on changes in BF mass could not be observed in this study.

After transplantation, patients generally have fewer dietary restrictions and experience improved appetite with decreased uremia and better kidney function. Therefore, it is not surprising that studies have found dietary intake after transplant was characterized by increased mean total fat and carbohydrate intake.^{2,21} In our study, fat intake and percentage calories from fat were increased; however, carbohydrate intake was decreased, which could have contributed to the maintenance or a slightly reduced total calorie intake. Physical activity and energy expenditure are other factors that regulate body weight after transplant. It has been suggested that fear of damaging their new kidney, residual effects of renal failure, or the effects of immunosuppression on muscle function and structure might hinder increasing physical activity after kidney transplantation.^{33,34} While we found an increase in the number of days of activity among our study participants, the level of activity remained sedentary with less than 3 days of moderate activity, and there was no change in average energy expenditure from the baseline measure. It could be inferred that although some participants may try to increase physical activity, their efforts are not enough to induce a significant increase in energy expenditure.

A limitation of this study is the relatively small number of participants and the lack of statistical power. Nevertheless, the current research is unique because it is based on the paired data, baseline and 12 months after transplant, and compared 2 different measurement methods for obesity including BMI and BF composition from DXA. Although DXA measures are an excellent measure to determine body composition, there are limitations associated with DXA measures in kidney transplant recipients. For example, fluid shifts occur once the kidney begins functioning. To minimize this concern, all DXA measures were obtained as close as possible to discharge from the hospital (usually 4–5 days posttransplant). Additional findings related to gender and race differences in posttransplant changes in weight and their relationships with dietary intake and physical activity after kidney transplantation could provide direction for future research and clinical practice.

Conclusion

Our study findings highlight the significant increases seen in weight, BMI, and measures of BF mass at 12 months following kidney transplantation, particularly for women and AAs. This study provides insights into how BMI and body weight reflect different components of BF mass, which are particularly relevant to transplant recipients who are at risk for cardiovascular disease. As there is no universal standard for the use of BF mass measures to categorize obesity, additional research is warranted to further explicate the clinical application of these measures.

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Figure 1.

Comparison of body mass index and percentage body fat as classification for obesity at baseline and 12 months posttransplant. The number of participants classified as obese according to percentage body fat by DXA is higher than the number classified as obese by BMI at both time points.

Table 1.

Characteristics of Kidney Transplant Recipients at the Time of Transplantation (Baseline) and 12 Months Posttransplant.^a

Characteristics	Baseline	12 Months	P Value
Age at transplant, mean (SD), years	53.2 (10.8)		
Gender: male, n (%)	26 (50.0)		
Race, n (%)			
AA	30 (57.7)		
Caucasian	22 (42.3)		
Donor type, n (%)			
Deceased	42 (80.8)		
Living	10 (19.2)		
Weight, mean (SD), kg	79.3 (17.8)	83.0 (21.0)	.009
>10% weight gain, n (%)		19 (36.5)	
Body mass index, mean (SD)	27.5 (4.7)	28.7 (5.7)	.009
Hypertension, n (%)	51 (98.1)	47 (90.4)	
Diabetes, n (%)	13 (25.0)	19 (36.5)	
Dyslipidemia, n (%)	14 (26.9)	25 (48.1)	
Medication, mean (SD), mg/d			
Mycophenolate mofetil	1753.8 (348.8)	1224.9 (727.9)	
Tacrolimus	4.7 (2.7)	6.2 (4.2)	
Prednisolone	17.9 (4.1)	4.8 (2.6)	

Abbreviations: AA, African American; SD, standard deviation.

^an = 52.

Table 2.

DXA Measures of Body Mass Composition at Baseline and 12 Months Posttransplant.

DXA Measures Mean (SD)	Total Group (n = 52)			Men (n = 26)			Women (n = 26)			AA (n = 30)			Caucasian (n = 22)		
	Baseline	12 Months	P Value	Baseline	12 Months	P Value	Baseline	12 Months	P Value	Baseline	12 Months	P Value	Baseline	12 Months	P Value
Total body mass (kg)	79.3 (17.8)	83.0 (21.0)	.009	89.9 (15.8)	93.0 (20.5)	.164	68.7 (12.8)	72.9 (16.1)	.015	79.3 (18.1)	84.9 (21.2)	.002	79.3 (17.8)	80.4 (20.7)	.616
BMI (kg/m ²)	27.5 (4.8)	28.7 (5.7)	.009	28.8 (4.5)	29.7 (5.7)	.202	26.2 (4.7)	27.8 (5.8)	.016	27.7 (4.8)	29.6 (6.1)	.001	27.2 (4.7)	27.5 (5.2)	.746
Total body fat mass (kg)	24.9 (8.4)	28.9 (12.0)	<.001	24.6 (8.6)	28.8 (13.1)	.007	25.1 (8.3)	29.0 (11.1)	.008	24.5 (9.3)	29.7 (13.2)	<.001	25.3 (7.1)	27.8 (10.4)	.110
% Total body fat mass (%BF)	31.3 (8.0)	34.0 (9.3)	.001	26.7 (6.1)	29.3 (8.6)	.015	35.9 (6.9)	38.6 (7.5)	.028	30.6 (8.9)	33.9 (10.4)	.003	32.2 (6.6)	34.1 (7.8)	.123
Trunk fat mass (kg)	13.1 (5.2)	15.4 (7.4)	<.001	13.6 (5.7)	16.1 (8.4)	.013	12.5 (4.7)	14.7 (6.4)	.005	12.6 (5.4)	15.5 (7.9)	<.001	13.7 (5.0)	15.2 (6.7)	.114
% Trunk fat mass (%TF)	31.8 (8.4)	35.0 (10.6)	.001	28.3 (7.8)	31.4 (11.0)	.027	35.2 (7.8)	38.7 (9.0)	.009	31.2 (9.5)	35.0 (11.8)	.004	32.6 (6.8)	35.1 (9.0)	.062
Total lean body mass (kg)	54.4 (13.5)	54.0 (12.7)	.586	65.2 (9.1)	64 (8.5)	.368	43.6 (6.9)	44.0 (7.0)	.616	54.7 (13.1)	55.0 (12.1)	.776	53.9 (14.3)	52.6 (13.7)	.315

Abbreviation: AA, African American; %BF, percentage of body fat; BMI, body mass index; DXA, dual-energy X-ray absorptiometry; SD, standard deviation; %TF, percentage of trunk fat.

Table 3.Daily Dietary Intake and Weekly Physical Activity at Baseline and 12 Months Posttransplant.^a

	Baseline, Mean (SD)	12 Months, Mean (SD)	P Value
Kilocalories (kcal)	1616 (585.1)	1572 (693.8)	.601
Fats (g)	68.3 (26.2)	69.6 (31.6)	.745
Calories from fat (%)	37.2 (7.1)	40.0 (6.6)	.033
Proteins (g)	68.2 (24.4)	69.0 (28.3)	.854
Calories from protein (%)	17.7 (3.8)	18.2 (4.3)	.400
Carbohydrates (g)	186.4 (82.3)	170.3 (88.2)	.152
Calories from carbohydrates (%)	45.1 (8.4)	42.1 (8.5)	.031
Days of activity (day/week)	1.9 (2.3)	2.8 (2.3)	.018
Moderate (min/week)	170.2 (277.8)	271.8 (475.6)	.161
Hard (min/week)	2.3 (11.7)	14.7 (62.0)	.168
Average energy expenditure (METs)	32.6 (1.6)	33.3 (2.4)	.075

Abbreviations: METs, metabolic equivalents; SD, standard deviation.

^a
n = 52.