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Exploring problems in following the hemodialysis diet, and their relation to energy and nutrient intakes: The Balance Wise Study

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Abstract

Objective—To identify the problems experienced by hemodialysis (HD) patients in attempting to follow the HD diet, and their relation to energy and nutrient intakes.

Design—Cross-sectional analysis of baseline data from the BalanceWise Study.

Setting—Community-dwelling adults recruited from outpatient HD centers.

Subjects—After excluding participants with incomplete dietary analyses (n = 50), 140 community-dwelling African American and white (40/60%) men and women (52/48%) on chronic intermittent HD for at least three months (median three years) were included.

Intervention—Participant responses, on a 5-point Likert scale ranging from “not at all a problem” to “a very important problem for me”, to 34 questions pertaining to potential barriers to following the HD diet in the previous two months were classified as either a problem (1) or not a problem (2–5).

Main Outcome Measure—Energy and nutrient intakes determined using the Nutrition Data System for Research® based on three, non-consecutive, unscheduled, two-pass 24-hour dietary recalls collected on one dialysis and one non-dialysis weekday, and one non-dialysis weekend day.

Results—More than half of participants reported having problems related to specific behavioral factors (e.g., feeling deprived), technical difficulties (e.g., tracking nutrients) and physical condition (e.g., appetite), but issues of time and food preparation, and behavioral factors tended to be most deterministic of reported dietary intakes. Longer duration of HD was associated with lower intakes of protein, potassium, and phosphorus (p <0.05).

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Conclusion—Registered dietitian nutritionists should consider issues of time and food preparation, and behavioral factors in their nutrition assessment of HD patients, and should continually monitor HD patients for changes in protein intake that may occur over time.

INTRODUCTION

The kidneys are key homeostatic organs. Among their many functions, the kidneys maintain the body's balance of several minerals (e.g., sodium, potassium and phosphorus). Consequently, patients with end-stage renal disease (ESRD) are prone to mineral imbalances, which greatly contribute to morbidity and mortality^{1–3}. Restricting the dietary intake of these minerals may help ESRD patients to maintain mineral balance and avoid complications; however, dietary restriction can also result in a nutritionally inadequate diet. Protein-energy wasting is especially problematic for ESRD patients who receive chronic intermittent hemodialysis (hereto referred to as HD patients) because of protein turnover in metabolic stress, protein losses from frequent blood testing and in dialysate⁴, and inadequate intake related to dialysis treatment⁵.

Although numerous factors are thought to contribute to dietary nonadherence in HD patients, including resource adequacy, social network, behavioral factors, technical difficulties, and physical condition, no studies have described the relative importance of these factors in relation to reported dietary intakes of energy and key nutrients in HD patients. Identifying the major barriers to following the HD diet, and the key determinants of energy and nutrient intakes in HD patients can help to improve nutrition assessment, and lead to the development of appropriate dietary interventions.

To provide insight into the problems experienced by HD patients in attempting to follow the HD diet, and their relation to energy and nutrient intakes, we analyzed data from the BalanceWise Study, a technology-supported behavioral intervention trial conducted in African American and white, male and female HD patients.

METHODS

Study Participants

This study is a secondary data analysis of data collected as part of the baseline assessment of participants in the BalanceWise study⁶. BalanceWise participants were recruited from three dialysis chains in Pennsylvania, U.S.A. (DaVita HealthCare Partners, Inc., Dialysis Clinic Inc., and Fresenius Medical Care North America), and included only non-institutionalized patients over 18 years of age who had been receiving intermittent HD for at least three months, and who were deemed appropriate for the 16-week intervention. Patients who were expected to discontinue HD treatment at the center (e.g., changing centers, kidney transplant), or who had a life expectancy of less than 12 months were excluded. In addition, patients who were unable to use the hand-held device and software that were being used for the intervention due to English-proficiency, or physical/cognitive limitations were excluded. Of 848 HD patients, 257 were eligible, and 190 consented to study. For our main analyses, we excluded participants who missed dietary collection days ($n = 50$), which left 140 (74%)

participants for study. The University of Pittsburgh Institutional Review Board approved the BalanceWise Study.

Dietary Assessment

Dietary intakes were collected at baseline for three non-consecutive days in a two-week period using the two-pass 24-hour dietary recall method, as described previously⁷. To account for day-to-day variability in intakes, dietary recalls were conducted on two weekdays (one HD day, one non-HD day), and one weekend, non-HD day. The two initial recalls were conducted in person, and the third recall was conducted by telephone. To minimize bias, in all instances, dietary recalls were unscheduled. The nutrients content of dietary recalls were estimated using the Nutrition Data System for Research®⁸. Energy intakes were analyzed as absolute values and in relation to edema-free adjusted body weight (described below), and nutrients were analyzed in relation to energy intake.

To better understand perceived difficulties and determinants of dietary intake in this population, participants were asked to complete a 34-item questionnaire pertaining to problems they encountered in following the HD diet in the previous two months, including issues of resource adequacy, social network, behavioral factors, technical difficulties, and physical condition⁹. Although participants responded on a five-point Likert scale ranging from 1 (not a problem at all) to 5 (a very important problem for me), we analyzed their responses as not a problem (1) and a problem (2–5) due to the limited number of participants who indicated problems with many of these issues.

Covariates

Sociodemographic and clinical characteristics of participants were collected at baseline through a questionnaire. Body weight and height were also measured at each dialysis treatment, and were used to calculate edema-free adjusted body weight (aBW_{ef}) and body mass index (BMI). The aBW_{ef} was used to estimate BMI (kg/m^2), and was calculated as per the K/DOQI™ Nutrition in Chronic Renal Failure guidelines as:

$$aBW_{ef} = BW_{ef} + [(SBW - BW_{ef}) \times 0.25],$$

where BW_{ef} is the post-dialytic body weight, and SBW is the standard body weight, defined as the 50th percentile of body weight for gender, height and body frame size from the National Health and Nutrition Examination Survey (NHANES) II¹⁰.

STATISTICS

Study parameters were summarized as number (percent) for categorical variables, mean $\pm$ standard deviation for normally distributed continuous variables, and median (interquartile range) for continuous variables that were not normally distributed. Normality of continuous variables was determined using the Shapiro-Wilks test, and through assessment of frequency distribution graphs.

The univariate associations of sociodemographic and clinical variables, and self-reported problems in following the HD diet with energy and nutrient intakes were analyzed using

Pearson's or Spearman's correlation coefficient tests for continuous variables, and independent two-sample t-tests and Wilcoxon rank sum test for categorical variables, as appropriate. Nonlinear correlations and major outliers were identified graphically through scatterplots and/or boxplots. When influential outliers were identified, tests were rerun after winsorizing those participant's values to the 95th percentile. Because two participants had influential outliers for sodium (one participant) and/or potassium (both participants) that impacted the results, the winsorized values were used instead.

The associations of sociodemographic and clinical variables with dietary intake variables were also assessed by multivariable linear regression analysis, adjusting for gender, race and age. For these analyses, usual/influential participants were identified based on studentized residual and leverage values. When analyses were rerun with these participants removed, all of the findings were similar, except for the association of reported potassium intake with age, which became notably stronger ($\beta=3.9$, $p=0.05$ to $\beta=5.0$, $p=0.01$) after a high leverage participant was removed. We additionally examined the normality of the residuals using the scatterplots of residuals with quartiles, and heteroscedasticity using the scatterplots of residuals with predicted values. Both reported dietary protein intake and dialysis duration were non-normally distributed continuous variables that exhibited non-linear relationships in some of the univariate analyses, and non-normally distributed residuals and/or heteroscedasticity in some of the multivariable analyses. Log-transforming their values generally corrected the non-normal distribution of residuals and heteroscedasticity, but did not change any of the outcomes.

Statistical analyses were conducted using Statistical Analysis Software® version 9.3 (SAS 9.3), and graphs were developed using Microsoft Excel® for Mac 2011.

RESULTS

Characteristics of Participants

Participants included males (52%) and females (48%) aged 62 ± 13 years that were African American (40%) or white (60%), and had been on hemodialysis for a median duration of about three years with 12% indicating prior kidney transplant (Table 1). In addition to kidney disease, many patients were obese (BMI ≥ 30.0 kg/m², 46%) and hypertensive (80%), and reported a history of cardiovascular disease (51%) and/or type 2 diabetes (47%) (Table 1). Many participants had more than a high-school education (43%), but very few were currently employed (14%) with most earning $< \$30,000$ per year (59%), and about one-third reporting insufficient income to meet their needs (32%) (Table 1).

Problems Following the HD Diet

When asked to what extent they follow the HD diet during a usual week (0–100% at 10% intervals), nearly half of participants reported that they follow the diet half the time ($n=31$ (26%)) or less than half of the time ($n=23$ (19%)). Only 19% of participants indicated that they followed the HD diet 90–100% of the time. Of the 34 potential barriers to dietary adherence that were investigated (Figures S1–S5), more than half of the participants reported problems over the last two months with eating away from home (67%), lacking an

appetite (66%), craving salty foods (64%), being too tired to cook (59%), finding the HD diet bland and tasteless (57%), tracking nutrient intakes (56%), feeling deprived with dietary restrictions (55%), and motivating themselves to eat the right foods (53%).

Determinants of Dietary Intakes

The associations of sociodemographic and clinical factors with reported energy and nutrient intakes are outlined in Table 2. Compared to females, males reported higher energy intakes ($p<0.0001$), and had corresponding higher intakes of protein, sodium, potassium, and phosphorus ($p<0.0001$) that were no longer significant when analyzed in terms of nutrient density. Reported energy intakes did not differ by race or age, but African Americans and older participants tended to have more phosphorus ($p=0.002$ and $p=0.02$), and potassium ($p=0.02$ and $p=0.006$) dense diets. The associations between race and dietary potassium, and age and dietary phosphorus were no longer statistically significant after adjusting for gender, race and age. Of note, in these multivariable analyses, African American race was associated with higher energy intake overall and in relation to body weight ($p<0.05$).

Although energy or nutrient intakes were not associated with education or income, participants who were currently employed reported higher energy intakes in unadjusted (+281 kcal/d, $p=0.01$) and gender, race and age adjusted analyses ($p<0.05$). In addition, married participants reported higher potassium intakes (+139 mg/1,000 kcal/d, $p=0.004$; gender, race and age adjusted $p<0.01$), and smokers reported higher protein intakes (median 19.1% kcal) than non-smokers (median 16.7% kcal, $p=0.02$ for unadjusted and adjusted analyses).

Of the clinical variables assessed, hypertension and history of renal transplant were not associated with reported dietary intakes ($p>0.05$). Relative energy intake (kcal/kg body weight) tended to be lower among participants with higher BMIs ($r = -0.56$, $p<0.0001$ for unadjusted and adjusted analyses), and a history of cardiovascular disease (-1.9 kcal/kg, $p=0.08$; gender, race and age adjusted $p=0.03$). Participants who had been on dialysis longer reported diets that were lower in protein ($p=0.006$), potassium ($p=0.0005$) and phosphorus ($p=0.009$), and higher in sodium ($p=0.03$), and participants with diabetes reported diets that were higher in protein ($p=0.02$), sodium ($p=0.007$), potassium ($p=0.0006$), and phosphorus ($p=0.001$) (Table 2). Further, although the reported energy intake did not differ by diabetes status, those with diabetes reported lower energy intakes in relation to their body weight ($p=0.0002$). These relationships remained statistically significant after adjusting for gender, race and age, except for the correlation between dialysis vintage and sodium density.

Nine problems in following the HD diet were associated with the dietary variables of interest (Table 3). Half of these problems were directly linked to challenges in time availability, grocery shopping and food preparation. Specifically, being too tired to cook was associated with lower energy intake ($p=0.02$), whereas shopping difficulties, grocery store being too far away ($p=0.03$) and trouble selecting the right foods ($p=0.02$), and lacking the time to cook, healthy foods ($p=0.04$) or otherwise ($p=0.03$), were associated with lower potassium intake. Other barriers related to dietary intakes were mostly behavioral. Difficulty adopting new dietary habits (due to changing health) and controlling intake when busy or feeling overwhelmed were associated with lower relative estimated energy intakes (per kg,

p=0.01 and p=0.0009), and feeling deprived when restricting and using food as a treat or reward were associated with lower sodium (p=0.04) and potassium intakes (p=0.03), respectively. Of interest, none of the 34-problems assessed were associated with reported protein or phosphorus intakes (p>0.05), and self-reported adherence to the HD diet was only associated with reported sodium intake ($\rho=-0.22$, p=0.02).

DISCUSSION

The results of this study contribute to our understanding of the problems that HD patients have in following the HD diet, and how they relate to dietary intakes of energy and several key nutrients in this population. Further, because the BalanceWise study included a relatively large and diverse population of patients, we were able to identify sociodemographic and clinical factors also related to diet. These findings are of direct relevance to renal registered dietitian nutritionists, and provide several avenues for future investigation.

Although the prevalence of many barriers to dietary adherence in HD patients has been described previously (especially anorexia), few studies have attempted to link multiple barriers to reported dietary intakes. Sehgal et al (1998) examined the association of several medical, behavioral and socioeconomic barriers to dietary adherence with biomarkers of protein intake (normalized catabolic rate) and status (serum albumin) in a similar cohort of HD patients.¹¹ In this study, low protein catabolic rate was independently associated with poor appetite, and low serum albumin was independently associated with lack of knowledge of protein-containing foods and needing help with shopping and cooking. In their subsequent randomized clinical trial¹², compared to standard care, a multidisciplinary, tailored intervention that targeted individual nutritional barriers resulted in a modestly higher increase in serum albumin concentration, along with a greater proportion of participants overcoming lack of knowledge, and difficulties shopping and cooking, but not lack of appetite. Of interest, the less barriers remaining at the end of the study, the more the serum albumin concentration increased.

This finding suggests that factors other than prevalence (poor appetite was most common), such as the ease with which a barrier can be overcome, and its relation to dietary consumption are important considerations when determining potential targets for intervention. Indeed, of the eight barriers present in more than half of participants, only two (being too tired to cook and feeling deprived with dietary restrictions) were associated with reported dietary intakes in our study sample. Although we attempted to classify dietary adherence problems as being related to resource adequacy, social network, behavioral factors, technical difficulties or physical condition, it did not appear that any of these groups of problems were more common, or more likely to be associated with reported dietary intakes. Retrospectively, there is some indication that challenges related to time availability, grocery shopping and food preparation, and certain behavioral factors comprised the major determinants of dietary intakes.

These findings are intriguing, yet somewhat unexpected given that only a small subset of the 34 problems explored – all of which were expected to be related to diet - were associated

with energy or nutrient intakes in this study. Of note, our sample consisted of urban African American and white HD patients who were suitable for a technology-assisted dietary intervention, and other barriers to adherence may be more deterministic of dietary intake in other populations of HD patients (e.g., Hispanic, Asians). Regardless, our findings suggest that many barriers that are often unaddressed in most dietary intervention studies may be important determinants of dietary intakes in HD patients. Indeed, most dietary intervention studies are based on the assumption that lack of knowledge or motivation are the key contributor to dietary nonadherence, which may not be the case¹³. Interventions that specifically targets time management and skills for grocery shopping and meal preparation, and emotional regulation may be important, largely untapped means of improving dietary adherence in HD patients, which should be explored further. Recently, providing meals or dietary supplements during dialysis has been proposed as an overlooked opportunity to improve the nutrition status of HD patients¹⁴, and would certainly be in line with our current findings.

In addition to these factors, we found that sociodemographic and clinical characteristics of participants were associated with dietary intakes. Of particular interest, longer dialysis vintage was associated with lower protein intakes, suggesting that protein-energy wasting may be of greater concern as patients progress on HD. Although dialysis duration was not associated with protein catabolic rate or serum albumin concentration as in the study by Sehgal et al (1998)¹¹, similar associations of protein intake with dialysis duration were observed in a study of HD patients in India.¹⁵ In this study, patients who were on HD for greater than six months had higher energy intakes, but tended to have lower protein intakes (48 g/d vs 52 g/d, $p = 0.06$), which was significant for high-biological value protein. Diagnosis with diabetes was also highly deterministic of reported dietary intakes in our study sample. Patients with diabetes reported diets that were more nutrient dense in protein, sodium, potassium and phosphorus, which tended to be lower in relative energy intake. These differences may reflect ongoing or historical dietary recommendations for patients with diabetes. Indeed, participants who reported difficulties adopting new dietary habits due to constantly changing health also reported lower relative energy intakes.

The study sample that we examined was about one-half of the eligible study population, and only about one-sixth of all HD patients, and therefore, likely represents a biased perspective of the problems experienced by patients following the HD diet. However, ineligibility for or lack of interest in a dietary behavioral intervention were the primary determinants of non-participation in the BalanceWise Study, which better defines our true target population. For example, HD patients with a prognosis of less than one year were excluded to limit their burden, but these patients may not be appropriate for an intensive lifestyle intervention to reduce sodium intake. Some loss of representativeness may have been introduced by eliminating participants with incomplete dietary data, but this was determined to be necessary to retain internal validity of our results because reported energy and nutrient intakes are significantly different on dialysis and non-dialysis days⁷. Even with our efforts to provide internally valid conclusions, the findings of this study are preliminary and should be interpreted cautiously, as we examined many relationships (risk of β -errors). In addition, we dichotomized problems in following the HD diet into 'not at all a problem' (1) and 'a problem' (2–5), and other cutoffs may have generated different findings. Further, dietary

analyses contain substantial random measurement error (risk of α -errors), particularly for sodium and phosphorus^{16–17}, and the 24-hour recall method used may have systematic recall bias that could lead to α - and/or β -errors. While nutritional biomarkers can complement dietary assessment in most populations (e.g., urinary sodium and phosphorus, serum albumin), these indices are unavailable and/or greatly confounded in HD patients¹⁸. Lastly, although the problems in following the HD diet were framed in the previous two months, their collection occurred alongside the dietary analysis, and therefore, the possibility of reverse causality (e.g., high sodium intakes increasing the time spent at the dialysis center to remove excess fluid) cannot be ruled out.

PRACTICAL APPLICATIONS

In this study, we provided a comprehensive summary of the problems experienced by HD patients in attempting to follow the HD diet, and have identified time, food preparation and behavioral factors as potentially important determinants of dietary intakes in this population. Our findings suggest that the primary approach of teaching patients about the dietary sources of key nutrients, while necessary, may not be sufficient to helping patients adhere to the HD diet. Although there is still insufficient evidence to draw firm conclusions, it may be worthwhile examining whether renal dietitians are adequately assessing these factors. In addition, we observed potentially important lower protein intakes with longer dialysis vintage, which supports the findings of others and warrants further investigation. In the interim, renal dietitians should consider these factors in their nutrition assessment of HD patients, and should continually monitor HD patients for changes in protein intake that may occur over time.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Table 1

Characteristics of Participants in the BalanceWise Study

Variable	n	Values
Age, years (mean $\pm$ SD)	140	62 $\pm$ 13
Body mass index, kg/m ² (mean $\pm$ SD)*	140	30.3 $\pm$ 7.7
Relative energy intake, kcal/kg/d (mean $\pm$ SD)	140	16.5 $\pm$ 6.4
Energy intake, kcal/d (mean $\pm$ SD)	140	1360 $\pm$ 456
Protein intake, % kcal (median, IQR)	140	17 (15–21)
Sodium intake, mg/1,000 kcal (mean $\pm$ SD)	140	1730 $\pm$ 453
Potassium intake, mg/1,000 kcal (mean $\pm$ SD)	140	1130 $\pm$ 282
Phosphorus intake, mg/1,000 kcal (mean $\pm$ SD)	140	571 $\pm$ 123
Dialysis duration, months (median (IQR))	128	35 (15–67)
Male gender (n (%))	140	73 (52%)
Race (n, (%))	139	
African American		56 (40%)
Caucasian		83 (60%)
Smoke cigarettes, current (n, (%))	140	22 (16%)
Education, more than high school (n, (%))	140	60 (43%)
Currently employed (n, (%))	140	19 (14%)
Income, \$30,000/year (n, (%))	103	42 (41%)
Meets needs (n, (%))	133	90 (68%)
Married (n, (%))	140	62 (44%)
History of CVD (n, (%))	140	72 (51%)
Diabetes (n, (%))	139	66 (47%)
High blood pressure (n, (%))	140	112 (80%)
Prior renal transplant (n, (%))	140	17 (12%)

* Body mass index was estimated using edema-free adjusted body weight, calculated as the post-dialytic weight minus 25% of the difference between their post-dialytic weight and their ideal weight (50th percentile of weight for gender, height and body frame size from the National Health and Nutrition Examination Survey II) (Kopple, 2001).

Table 2
Associations of sociodemographic and clinical factors with reported energy and nutrient intakes in the BalanceWise Study

	Relative Energy (kcal/kg/d)	Energy (kcal/d)	Protein (% kcal)	Sodium (mg/1,000kcal)	Potassium (mg/1,000 kcal)	Phosphorus (mg/1,000 kcal)
Female gender	-1.7, p=0.11	-335, p<0.0001***	-0.2, p=0.93	-96, p=0.21	+9, p=0.86	+5, p=0.82
African Am. race	+1.9, p=0.08*	+124, p=0.12*	+0.5, p=0.47	-26, p=0.74	+119, p=0.02	+66, p=0.002*
Diabetes	-4.0, p=0.0002***	-129, p=0.10	+2.0, p=0.02**	+206, p=0.007***	+163, p=0.0006***	+67, p=0.001***
Age, in years	-0.02, p=0.77	-0.10, p=0.22	+0.06, p=0.47	-0.15, p=0.07	0.23, p=0.006*	+0.19, p=0.02
Dialysis vintage	+0.07, p=0.44	+0.05, p=0.57	-0.24, p=0.006**	+0.19, p=0.03	-0.30, p=0.0005**	-0.23, p=0.009**

Am., American

Values are differences in average or median reported energy and nutrient intakes between groups for categorical independent variables (female vs. male, African American vs. white, diabetes vs. no diabetes), Pearson's correlation coefficients for normally distributed continuous variables (age), and Spearman's correlation coefficient for non-normally distributed variables (protein and dialysis vintage). Differences between groups were assessed using independent two-sample t-test and Wilcoxon rank sum test (protein).

* p<0.05,

** p<0.01,

*** p<0.001 based on multivariable regression analysis, adjusting for gender, race and age

Table 3

Associations of problems in following the hemodialysis diet with reported energy and nutrient intakes in the BalanceWise Study

Dietary Variable	Self-reported problem	Values
Relative Energy (kcal/kg/d)	When I am busy or feeling overwhelmed, I find it difficult to control what I eat (n=140)	-2.8, p=0.009
	It is hard to start new dietary habits because my health changes so often (n=140)	-2.9, p=0.01
Energy (kcal/d)	Sometimes I am too tired to cook (n=140)	-175, p=0.02
Sodium (mg/1,000 kcal)	I feel deprived when I have to restrict what I eat (n=139)	-159, p=0.04
Potassium (mg/1,000 kcal)	I use food as a reward or treat to myself (n=140)	-106, p=0.03
	I find it difficult to select the right foods when shopping (n=139)	-113, p=0.02
	It is hard to eat a healthy diet because the nearest grocery store is too far away (n=140)	-151, p=0.03
	I do not have time to cook (n=140)	-116, p=0.03
	I do not have the time to cook healthy foods (n=140)	-111, p=0.04

Values are differences in average reported energy and nutrient intakes between participants with and without the reported problem