Title

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Self-reported, interview-assisted diet records underreport energy intake in maintenance hemodialysis patients

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Abstract

Objective—Studies suggest that maintenance hemodialysis (MHD) patients report dietary energy intakes (EI) that are lower than what is actually ingested. Data supporting this conclusion have several important limitations. The present study introduces a novel approach of assessing underreporting of EI in MHD patients.

Design—Comparisons of EI of free-living MHD patients determined from food records to their measured energy needs.

Setting—Metabolic research ward.

Subjects—13 clinically stable MHD patients with unchanging weights whose EI was assessed by dietitian-interview-assisted 3-day food records.

Intervention—EI was compared to 1) patients' resting energy expenditure (REE), measured by indirect calorimetry, and estimated total energy expenditure (TEE), and 2) patients' dietary energy requirements (DER) measured while patients underwent nitrogen balance studies and consumed a

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Conflict of Interest:

Bryan B. Shapiro, Rachelle Bross, Gillian Morrison, Kamyar Kalantar-Zadeh, and Joel D. Kopple declare that they have no conflict of interest.

constant energy diet in a research ward for a mean duration of 89.5 days. DER was calculated as the actual EI during the research study corrected for changes in body fat and lean body mass measured by Dual X-Ray Absorptiometry (DEXA).

Main Outcome Measure—Underreporting of energy intake was determined by an EI:REE ratio <1.27 and an EI:TEE ratio or EI:DEE ratio <1.0.

Results—Seven of the 13 MHD patients studied were male. Patient's ages were 47.7±SD 9.7 years; BMI averaged 25.4±2.8 kg/m^2, and dialysis vintage was 53.3±37.1 months. The EI:REE ratio (1.03±0.23) was significantly less than the cut-off value for under-reporting of 1.27 (p=0.001); 12 of 13 patients had EI:REE ratios <1.27. The mean EI:TEE ratio was significantly less than the cut-off value of 1.0 (0.73±0.17, p<0.0001), and 12 MHD patients had EI:TEE ratios <1.0. The EI:DER ratio was also less than 1.0 (0.83±0.25, p=0.012), and 10 MHD had EI:DER ratios <1.0.

Conclusion—Dietitian interview-assisted diet records by MHD patients substantially underestimate the patient's dietary energy intake.

Keywords

Hemodialysis; chronic kidney disease; dietary energy intake; dietary diaries; food records

INTRODUCTION

Protein-energy wasting (PEW) is a highly prevalent complication of maintenance hemodialysis (MHD) patients[1–4] and is associated with much higher mortality.[5, 6] Since reduced energy intake may contribute to PEW, it is important to assess dietary energy intake in MHD patients in their normal outpatient environment. A question arises as to the degree of accuracy of dietary food records or dietetic interviews for assessing energy intake in MHD patients. To the authors' knowledge, four previous studies have addressed this question. One older study demonstrated that in MHD patients whose reported calorie intakes were lower (below 30 kcal/kg/day) than the intakes routinely provided for hospitalized individuals, little change in their body weight was observed over a period of several months.[7] Three subsequent studies have more directly assessed the question of underreporting of energy intake in MHD patients.[8–10] All three of these studies were limited by comparing reported energy intake to previously published estimates of energy expenditure based upon the patients' body weights. Moreover, only one of these reports established that patients were weight stable at or during the time of study.[8] This is an essential component of a study assessing accuracy of reported dietary energy intakes, since a low reported energy intake is also consistent with an accurate report of energy intake with weight loss.

The current study presents a novel approach to investigate the accuracy of reported EI in MHD patients. Reported EI, determined by dietitian interview-assisted 3-day food records, was assessed in 13 clinically stable MHD patients who had stable post-dialysis body weights prior to, and during, the period of study. Two techniques were used to assess underreporting: 1) Comparing the patients' reported EI to their resting energy expenditure (REE) measured by indirect calorimetry and to a validated estimate of total energy expenditure (TEE), and 2)

Comparing the patients' reported EI to their actual dietary energy requirements (DER) for weight stability, measured under the strict protocol of a long-term (mean, 89.5 day) classical nitrogen balance study in which constant energy diets were meticulously prepared and fed to MHD patients for relatively long periods of time. DER was ascertained using the patients' actual EI during the study corrected for changes in the patients' body fat and lean mass as measured by DEXA. Underreporting was determined by an EI:REE ratio <1.27 or by an EI:TEE ratio or EI:DER ratio <1.0.

SUBJECTS AND METHODS

Study Overview and Subjects

This study was a component of an investigation of dietary protein needs in 13 clinically stable MHD patients who lived in the metabolic research ward (Clinical and Translational Science Institute, CTSI) at Harbor-UCLA Medical Center for an average of 89.5 days. Patients recruited for the metabolic study were selected from a pool of approximately 1040 eligible MHD patients undergoing dialysis treatment in twelve chronic hemodialysis centers in the South Bay area of Los Angeles. Patients were assigned, in random order, to receive diets providing about 0.6, 0.8, 1.0, 1.15 and 1.30 g protein/kg/day. Except for one protein intake fed to one patient for 11 days, each diet was fed for 16–22 days. All dialysate, feces and urine, if any, were collected continuously and about 4–5 additional 24-hour dietary intakes were prepared. These specimens were each analyzed for nitrogen. Patients were hemodialysis with Fresenius® dialyzers. Blood flows were 400mL/min; dialysate flows were 800mL/min, and glucose in dialysate concentrations were 200 mg/dL (182 mg anhydrous glucose/dL).

Patients were recruited from DaVita Dialysis Centers in Los Angeles, California and were selected for the study on the basis of the following criteria. Inclusion criteria: 1) Ages 25–65 years, 2) Men and women of all racial and ethnic groups, 3) MHD treatment three-times weekly for ≥6 months (at the time that the nitrogen balance studies commenced), 4) Serum albumin ≥3.6g/dl, 5) Serum hemoglobin ≥11g/dl, and 6) Relative body weight of 90–115% of NHANES II median body weights. Exclusion criteria: 1) Moderate-or-severe protein-energy wasting, 2) Existing cancer other than basal cell carcinoma, 3) Severe heart, lung or liver disease, 4) Poorly controlled hypertension or asthma, chronic systemic infection, active vasculitis or any systemic inflammatory process, symptomatic musculoskeletal disease or neuropathy, or amputations of the lower extremities, 5) Insulin-dependent or insulin-independent diabetes mellitus, 6) Pregnancy, 7) History of alcohol or drug abuse, 8) Treatment with L-carnitine or anabolic hormones within the previous 6 months, 9) Psychosis or inability to give informed consent or to follow the protocol.

This study was approved by the Institutional Review Board of the Los Angeles Biomedical Research Institute at Harbor-UCLA Medical Center (US Gov. Trials No. NCT02194114).

Free-Living Energy Intake

The patients' energy intake while living at home was assessed from an interview-assisted food record. Subjects were carefully instructed by a trained dietitian to record their total food intake for three consecutive days including at least one dialysis treatment day, at least one week day and at least one weekend day. Patients were instructed to record the quantity of all food and beverages consumed in household measures or by weight and to record methods of food preparation, brand names and ingredients of foods, and recipes of mixed dishes when possible. A dietitian reviewed the completed food record with each patient for clarification of food details and amounts. The dietary records and interviews and the metabolic studies of the patients were conducted during every season of the year. The 3-day food record was analyzed using Nutrition Data System for Research software (v4.06/34; Nutrition Coordinating Center, University of Minnesota, Minneapolis, MN). Post-dialysis body weights in the 13 MHD patients were recorded over a 2-month period that ended at the time these outpatient diaries and interviews measurements were conducted.

Resting Energy Expenditure (REE)

Assessments of REE were generally performed within 24–96 hours of completing the interview-assisted food records. Energy needs were measured under standard basal metabolic rate conditions by indirect calorimetry using an open-circuit, ventilated, computerized metabolic system (Vmax Spectra series model V29n, Sensor Medics Corporation/VIASYS health care, Yorba Linda, CA). Patients were admitted the night prior to the measurement and were fasted from 9:00 p.m. until after the test the following morning between 7:00 a.m. and 8:00 a.m. Patients rested for 30 minutes prior to and during the measurement in the supine position in a quiet, thermoneutral room with the lights semi-darkened. A transparent plastic hood was placed over the patients’ head with the vinyl skirt covering the torso and airflow. O_2 consumption, and CO_2 production were measured continuously for 30–40 minutes. Five minutes of data were allowed to expire before initiating formal data collection to allow for acclimation to the apparatus. Data points were collected every 30 seconds and steady-state was defined as 10 minutes during which the volume of oxygen consumed, expired ventilation (VE), and respiratory quotient (RQ) did not vary >7%. Resting energy expenditure was calculated using the following equation:

$$\text{Energy Expenditure (kcal/min)} = (3.82 \times VO_2) + (1.23 \times VCO_2) - (6.0 \times UNA)$$ [11]

where VO_2 is the rate of oxygen uptake (L/min), VCO_2 is the rate of carbon dioxide expiration (L/min), and UNA is the urea nitrogen appearance, assumed to be 6.0 mg/minute in MHD patients.[12]

Estimated Total Energy Expenditure (TEE)

TEE was determined using the formula 1.40 × REE,[13] which is based on a physical activity level (PAL) multiplier indicative of a sedentary or light activity lifestyle in normal people according to the World Health Organization[13] and in MHD patients.[4] The PAL ranges from 1.40 to 1.69 for sedentary or light physical activity. This formula is based on the approximations that each day patients sleep about 8 hours, sit for 8 hours, engage for 7 hours in light activity (washing, dressing, eating, driving cars for one hour, and short periods of standing), and walk for about one hour at varying paces without a load. Since studies indicate that MHD patients tend to be especially sedentary,[14–16] the lower limit of the PAL of 1.40 was used for our estimations of TEE.

Accuracy of Interview-Assisted Food Records

The accuracy of the reported energy intake was assessed in two ways. The first method was by comparing reported EI against measured REE and estimated TEE. An EI:REE ratio<1.27 was used as the cutoff value for defining people who underreport their EI, as employed in several previous studies,[8, 17, 18] based on demonstrations that under free-living conditions, it is highly unusual for total energy expenditure to fall below a factor of 1.27 multiplied by the basal metabolic rate of individuals.[19] Indeed, daily TEE is necessarily greater than the REE extrapolated to 24 hours, because of the daily physical activity of people and the specific dynamic action of ingested foods. Moreover, the EI from food records should approximately equal TEE, if body mass and composition (i.e. edema-free body weight, body protein, fat, and glycogen mass) is unchanging.[9] For this reason, an EI:TEE ratio <1.00 was also considered indicative of underreporting. In comparisons of EI to REE, reported intakes on dialysis day and non-dialysis day were also considered separately based on findings that reported energy intakes in MHD patients differ on these days.[20]

The second method by which underreporting was assessed was by comparing the reported EI to the calculated dietary energy requirements based on a prescribed foot intake and any changes in body fat and fat-free, edema free mass determined by dual x-ray absorptiometry (see below).

Food Prescription

The controlled diets for each patient were designed using ProNutra software (Viocare, Inc., Version 3.3.0.10, 2009, Princeton, NJ). Diets were calculated so that each patient received a constant energy intake throughout their study that was determined by modifying each patient's TEE according to their age, clinical status, and physical activity in the metabolic ward. The prescribed energy intake differed, at most, modestly from the TEE.

Diets provided about 0.6–1.3 g protein/kg body weight/day depending on the specific dietary study period and randomized order of administration of dietary protein. 30–35% of kcal were from fat with a polyunsaturated to saturated fat ratio of approximately 1:1. Carbohydrate intake varied depending on the amount of protein given, and fiber was approximately 20 g/day. The study diet did not exceed daily intakes of 3000 mg sodium, 3120 mg potassium, 1000 mg phosphorus, and 1400 mg calcium. Patients were given the multivitamin, Nephro-Vite®. The glucose content of hemodialysate was 200 mg/dL (about 182 mg/dL anhydrous glucose), and therefore there was considered to be essentially only a modest gain during hemodialysis treatments.[21] The patients were often in negative protein balance with lower protein diets and positive protein balance with higher protein diets. We estimate that overall during the course of the study, the various protein intakes should not have significantly influenced net protein balance.

Patients were fed three meals and one snack daily with breakfast, lunch and dinner. Each meal constituted 2/7th of the subject's daily energy and protein intake and the snack represented 1/7th of the daily energy and protein intake. Each patient was instructed to consume all food in its entirety. A spatula, squirt bottle, and/or the subjects tongue were used to ensure 100% consumption of foods and beverages at every meal. Patients consumed meals in their hospital rooms under the supervision of the CTSI nursing and research nutrition staff, and diet intake was recorded daily. Total consumption of all foods in the diet was strongly encouraged.

All foods for each patient were: 1) Prepared in the metabolic kitchen at the CTSI 2) purchased at the same time (except for perishables) to eliminate the risk of nutrient content changes during the 89 days, 3) weighed to the nearest one-hundredth of a gram, pre-portioned for 5 diet periods, and stored frozen until ready for use, and 4) homogenous in nature so that every meal was approximately equal in nutrient composition.

Activities that are usually uncontrolled such as standing, sitting, and walking were gauged by the dietitian through interviews at baseline in order to accurately prescribe the energy intake for each patient. In the research ward, patients were prescribed exercise on a stationary ergometer several times daily. Exercise was tightly controlled and the patient's typical free-living daily activity level, determined by a careful history, was designed to maintain neutral energy balance.

Dual X-Ray Absorptiometry (DEXA)

Fat mass, soft lean body mass (LBM, fat-free, edema-free mass) and bone mass were estimated by DEXA one hour post-dialysis using a Hologic Series Model QDR 4500A-XP scanner (Hologic Inc., Bedford, MA). The methods for DEXA assessment of body composition have been described elsewhere.[22, 23] Precision of body composition analysis was determined by daily spine phantom quality control assessments in addition to weekly quality control assessments using a tissue calibration step phantom composed of soft tissue equivalent materials and a whole body phantom. DEXA was measured at baseline (beginning of the metabolic study) and at the end of each of the five protein diets (periods 1–5, respectively) fed to each patient.

Dietary Energy Requirements (DER)

The prescribed energy intake during this 89-day study may have underestimated or overestimated the patients' true dietary energy requirements (DER) for stability in body energy sources. Hence, the prescribed energy intake was corrected according to the patient's estimated energy excesses or deficits as indicated by any changes during the study in body fat or protein mass, as measured by DEXA. Protein mass was estimated from lean mass. The energy equivalents of changes in fat and lean body mass were considered to be 9.297 kcal/g body fat and 1.027 kcal/g lean body mass, respectively.[24] These changes were subtracted from or added to the patient's constant dietary energy intake during the study to indicate the patient's DER. The patient's reported EI was then compared against this calculated DER using an EI:DER ratio of <1.0 as the cutoff value for defining under-reporters. This approach is based on the principle that in the presence of a stable weight and body fat and body protein), the reported EI should equal the DER.[9]

Statistical Methods

All reported data in this manuscript concerning body weight refer to post-dialysis body weight. One-tailed, one-sample t-tests were used to compare calculated values to a standard threshold of underreporting (1.0 for comparisons of EI to REE, and 1.27 for comparisons of both EI to TEE and EI to DER). Two-tailed, paired t-tests were employed to assess changes in body energy stores in the 13 patients over the course of the study. Statistical significance was set at p-value<0.05. Data are presented as mean±standard deviation. Statistical analyses were conducted using Stata Statistical Software: Release 12, 2011 (StataCorp LP, College Station, TX).

RESULTS

Of the approximately 25 MHD patients who were invited to participate in the study, 15 patients consented, of which 13 entered and completed the metabolic study. Seven of the 13 dialysis patients studied were male (54%). Patients' ages averaged 47.7±SD 9.7 years. BMI was 25.4±2.8 kg/m^2, and dialysis vintage was 51.9±33.1 months. Of the 13 patients studied, eight were non-Black Hispanic (62%), three were African-American (23%), one was Asian (8%), and one was Caucasian (8%). Post-dialysis body weights recorded in the 2-month period prior to the start of the study did not change significantly, from 67.4±12.5 kg to 67.0±12.1 kg (data not shown).

Mean reported energy intake (EI) from the interview-assisted food records, before the patient entered the research ward, was 1712±498 kcal/day (25.4±7.4 kcal/kg/day) (Table 1). The reported EI on dialysis days was not statistically different than on non-dialysis days (p=0.854). The mean REE of these 13 MHD patients, as calculated by indirect calorimetry, was 1676±331 kcal/day, which was not significantly different (p=0.307) from the REE predicted by the FAO/WHO energy requirement equations for normal people of the same age and gender (1556±249 kcal/day, 22.8±2.1 kcal/kg/day).[13] TEE in the 13 patients was 2346±463 kcal/day. Energy intake during the study averaged 2124±357 kcal/day (32.0±9.1 kcal/kg/day).

The self-reported EI calculated from interview-assisted food records was significantly less than the energy intake necessary to maintain body weight as estimated from the REE measurements. This indicates under-reporting of energy intake from the interview-assisted food records. The mean EI:REE ratio (1.03±0.23) was significantly less than the cut-off value of 1.27 (p=0.003) and was lower than 1.27 in 12 out of the 13 patients (Table 2). The EI:TEE ratio (0.73±0.17) was significantly less than 1.0 (p<0.0001) and was lower than 1.0 in 12 of the 13 patients, again indicating under-reporting.

Average patient post-dialysis weight decreased from baseline to the end of study by −0.63 kg; fat mass increased by +0.42 kg, and lean mass decreased by −1.05kg (Table 1). None of these changes were statistically significant according to paired t-tests. To attain more optimal body sodium and water in the MHD patients, adjustments were often made during the first diet period of study in daily water intake and the quantity of body water removed during hemodialysis. Consequently, we also examined the change in body fat mass and lean mass from the end of diet period 1 until the end of diet period 5 (duration of time, 71±7days). From the end of period 1 until the end of study, post-dialysis body weight decreased by −0.45 kg; fat mass increased by +0.53kg, and LBM decreased by −0.97 kg. Again, none of these changes were statistically significant. However, these changes in fuel mass reflect a net average change in fuel reserves of +4907 kcal (from increase in fat) and −999 kcal (from decrease in LBM) or a net mean of +3908 kcal per patient study (0.64±2.92 kcal/kg/day from the end of period 1 until the end of study).

The dietary energy requirements (DER), determined by long-term constant energy intakes in the metabolic ward adjusted for changes in body composition, were also significantly greater than the EI, by 388±547 kcal/day (5.4±7.4 kcal/kg/day) ($p<0.027$) (Table 2). The mean EI:DER ratio in the 13 MHD patients was 0.83±0.25 and was significantly less than 1.0 ($p<0.012$). In 10 of 13 MHD patients, the EI:DER ratio was less than 1.0. There was a strong correlation between the EI:DER ratio and the EI:TEE ratio ($r=0.863$, $p<0.0001$).

The average estimated glucose absorption and calorie intake from each hemodialysis was calculated as 35.6 g glucose and 137.2 calories or 58.8 kcal/day when time-averaged over the 7-day week. This suggests that the patients' total energy requirements were slightly greater than their DER. Since patients were treated with the same hemodialysate glucose concentration before entering the research ward, this glucose load should not affect the relationship between their interview-assisted food records and their REE, TEE or DER.

In order to examine whether patients with a higher body weight-for-height were more likely to underreport energy intake, we assessed the relation of the patients' BMI to their EI:REE, EI:TEE, and EI: DER ratios. No statistically significant trends were observed in these analyses, although the patient with the highest BMI (30.5) had the lowest EI:REE, EI:TEE, and EI:DER ratios (0.51, 0.37, and 0.39, respectively). In contrast, the other 12 patients, whose BMIs ranged from 20.7 to 29.0 kg/m^2, had mean EI:REE, EI:TEE, and EI:DER ratios of 1.07±0.18, 0.76±0.13, and 0.86±0.21, respectively.

DISCUSSION

The present study evaluated the accuracy of 3-day food records combined with interviews obtained by registered dietitians from MHD patients who were clinically stable and had stable body weights. This study offers the advantage of comparing the dietary energy intake (EI) in MHD patients, calculated from these interview-assisted food records, to two entirely different methods for assessing the dietary energy needs necessary to maintain body weight and composition. These methods are 1) Measuring resting energy expenditure (REE) by indirect calorimetry and then determining TEE using standard conversion factors, and 2) Feeding a constant dietary energy intake to clinically stable MHD patients, for extended periods of time (about 3 months), and estimating the dietary energy requirement (DER) by adjusting the energy intake for any changes in body fat and LBM. Each of these methods was then compared to the EI calculated in these same MHD patients from their interview-assisted food records.

The finding that the ratios for EI:REE and EI:TEE in our study were each significantly lower than the normal cutoff values suggest that these patients significantly underreported energy intake in their interview-assisted 3-day food records. These ratios were below the normal cutoff values in almost all (12) of the 13 patients. These 13 patients underreported energy intake by 19% and 27%, respectively. The statistically significant greater values for DER, compared to EI, provide further confirmation that energy intake by the interview assisted 3-day food records was under-reported. The DER was greater than the reported EI in 10 of the 13 MHD patients.

Both of our methods of comparing the interview-assisted food records indicate that between 77% and 92% of our MHD patients are under-reporters. These data are consistent with published data[8, 9] which suggest under-reporting as a possible explanation for the contradiction of stable body mass in MHD outpatients despite reported insufficient energy intakes. These data are also consistent with findings of under-reporting of energy intake by dietary food records in diverse, non-CKD populations.[17, 25–27] Most studies indicate that the energy needs of MHD patients are similar to normal people of similar age, body weight and gender who are engaged in sedentary or light physical activity.[11, 28] A few studies suggest that their resting energy expenditure might be slightly increased in these patients,[29, 30] Thus, the combination of all of the foregoing evidence strongly indicates that the low reported energy intakes in clinically stable MHD patients who have stable body weights cannot be explained by lower energy needs for MHD patients.

It can be argued that the difference between EI:TEE ratios and the cutoff value of 1.0 may be due to overestimating the physical activity level and thereby overestimating the TEE. However, if TEE were overestimated, then consistent weight gain throughout the study would have been observed as the subject would have been fed excess energy. Conversely, if TEE were underestimated as a result of underestimating physical activity, consistent weight loss would have been observed. In this sample of 13 subjects, most experienced small inconsistent weight fluctuations, most likely due to small variations among patients in TEE.

The interview-assisted food records indicated a dietary energy intake of 25.3 kcal/kg/day in our MHD patients. This is consistent with previous publications indicating that MHD patients report, on average, 20.7–29.8 kcal/kg/day intakes.[18, 31–34] It is puzzling that reported energy intakes on dialysis days were not different from non-dialysis days. This finding is in contrast to previous findings of reduced reported energy intake on dialysis day.[20] This discrepancy might be due to the relatively small number of food records obtained in the present study or possibly the healthier status of our MHD patients. The interview-assisted food records in our study indicated a daily protein intake of 1.03±0.32 g/kg, which is also consistent with previously published reported average protein intakes in MHD patients of 0.9–1.2g protein/kg/day.[33–35] We have not examined the accuracy of these reported protein intakes, and it is possible that the outpatient protein intakes are also under-reported.

The study has several strengths: First, patients were carefully monitored, and measurements were made by experienced nutritionists. Second, this study is unique in that highly defined diets providing a constant energy intake were meticulously prepared and fed to MHD patients for relatively long periods of time under the strict protocols of a classic nitrogen balance study. Third, the under-reporting of dietary energy intake by interview-assisted food records was confirmed by two methods that were independent of each other: REE and DER. Fourth, these two independents methods of assessment provided similar findings with regard to the degree of under-reporting of dietary energy intakes. The use of these techniques in chronic dialysis patients may be of particular importance because the doubly-labeled water technique (DLW), which has become well-established in people without kidney failure to compare their reported energy intake to their energy expenditure,[36, 37] would be very difficult to conduct in dialysis patients. Particularly, the loss of deuterium and oxygen-18 into dialysate during dialysis treatments would greatly complicate the use of this technique for people undergoing chronic dialysis.

This study also has several limitations: First, the estimated TEE we used is not an exact measure of TEE in individual patients since it was calculated as the product of REE and a general estimate of other energy-consuming activities. Second, the reported dietary energy intakes during the metabolic ward studies are calculated from databases of the calorie content of foods, rather than by direct measurements of the energy content of foods, for example as determined by bomb calorimetry.[38] Third, measures of LBM by DEXA can be affected by hydration status.[39] This is particularly relevant for MHD patients due to their marked inability to self-correct over-or-under-hydration.[40]

Our findings raise the question as to how dietary energy intake can be accurately assessed in MHD patients in an inexpensive, labor-efficient and convenient manner. O^{18} techniques for assessing energy expenditure appear highly reliable, but do not seem to be practical for outpatient clinical use.[41] Food frequency techniques also commonly underestimate food intake.[42, 43] Further research appears indicated to address this important question.

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TABLE 1

Nutrient Intake, Energy Expenditure, and Body Composition Measurements

Interview-Assisted Energy Intake*	
Energy, kcal/day (kcal/kg/day)	1712±498 (25.4±7.4)
Hemodialysis Day	1744±540 (26.2±8.8)
Non-Hemodialysis Day*	1706±498 (24.9±7.4)
Protein, g/day (g/kg/day)	69.6±21.3 (1.03±0.32)
Carbohydrates, g/day (g/kg/day)	219±94 (3.25±1.38)
Fat, g/day (g/kg/day)	63.6±18.9 (0.95±0.28)
Energy Assessments, kcal/day(kcal/kg/day)	
Measured Resting Energy Expenditure†	1676±331 (24.6±4.1)
Predicted Resting Energy Expenditure‡	1556±249 (22.8±2.1)
Total Energy Expenditure§	2346±463 (34.4±5.8)
Δ Body Energy Stores(End of Study minus Start of Period 1)¶	
Weight, kg	−0.63±1.96
Fat, kg (kcal/day//)	+0.42±1.92 (36.0±206.6)
Lean body mass, kg(kcal/day//)	−1.05±1.78 (−12.0±20.4)
Δ Body Energy Stores(End of Study minus End of Period 1)¶	
Weight, kg	−0.45±1.92
Fat, kg,(kcal/day//)	+0.53±1.56 (56.0±192.3)
Lean body mass, kg(kcal/day//)	−0.97±1.83 (−11.1±21.0)

Data presented as mean ±standard deviation.

*n=12 (the energy intake of one patient on non-dialysis day was not recorded)

†Measured by indirect calorimetry.

‡Predicted using the FAO/WHO energy requirement equations.[8]

§Estimated by the FAO/WHO equation 1.40 × REE[13]

//Calculated using changes in fat and lean mass measured by DEXA (9.297 kcal/g fat) & 1.027 kcal/g lean body mass[24] (see Methods).

¶No significant change in each body energy store was observed (p>0.05).

TABLE 2

Comparisons of Interview-Assisted Energy Intake to Resting and Total Energy Expenditure and to Dietary Energy Requirements

Comparison	Mean±SD	95% CI	Threshold*	# Patients < Threshold	*P-value*
EI:Resting Energy Expenditure	1.03±0.23	[0.89, 1.17]	1.27	12	0.001†
$EI_{DialysisDay}$:Resting Energy Expenditure	1.06±0.27	[0.91, 1.20]	1.27	9	0.007†
$EI_{Non\text{-}DialysisDay}$:Resting Energy Expenditure‡	1.00±0.27	[0.85, 1.15]	1.27	11	0.003†
EI:Total Energy Expenditure	0.73±0.17	[0.63, 0.83]	1.00	12	<0.0001†
EI:Dietary Energy Requirements	0.83±0.25	[0.69, 0.96]	1.00	10	0.012†

Ratios below this threshold indicate under-reporting of dietary energy intake.

† Ratios are significantly ($p<0.05$) below the threshold, and indicate underreporting.

‡ n=12 (the energy intake of one patient on non-dialysis day was not recorded)