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Near Infra-Red Interactance for Longitudinal Assessment of Nutrition in Dialysis Patients

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Objective: Serial nutritional assessment of dialysis patients is important because of the high incidence and prevalence of malnutrition in these patients. Near-infrared interactance (NIR) technology may provide a practical and reliable method to evaluate body fat and its changes over time in dialysis patients.

Design: Longitudinal study consisting of 2 cross-sectional measurements, 2 months apart.

Setting: Outpatient dialysis unit affiliated to a tertiary care community medical center.

Patients: Seventy-one dialysis patients (35 men, 36 women), 57 ± 15 years old, who have been on dialysis between 5 months and 11 years (43 ± 30 months). Twelve additional patients with similar features were studied during the second round.

Intervention: None.

Main outcome measures: NIR was used to estimate the body fat percentage. Other simultaneous measurements included subjective global assessment, anthropometric indices including midarm circumference, triceps and biceps skinfold thickness, and body mass index, and some laboratory values including albumin, transferrin, and cholesterol. NIR measurement was performed by placing a Futrex sensor on the nonaccess upper arm for several seconds, after logging the required individual data (sex, weight, height, and body frame), along with uniform physical activity levels for all patients, into a mini-computer.

Results: Seventy-one dialysis patients underwent nutritional and laboratory measurements. A second measurement round was performed 8 to 9 weeks after the first one and included 12 additional patients. Within each cross-sectional round, Pearson correlation coefficients (r) between the NIR score and nutritionally relevant variables were significant for anthropometric values (0.56 to 0.82) as well as low cholesterol and creatinine (0.22 to 0.30). The two serial NIR measurements on the same patients were highly consistent over the 2-month study interval ($r = 0.96$), whereas anthropometric values showed greater variability. The within-person coefficient of variation for NIR was low, indicating high consistency between 2 measurements. Moreover, the timing of the NIR measurement (predialysis *v* postdialysis) did not have any impact on consistency of the NIR results. The longitudinal changes of NIR had significant correlations with anthropometric and laboratory changes over time.

Conclusion: The NIR, which can be performed within seconds, may serve as a reliable and practical tool for objective measurements of nutritional status in hemodialysis patients. The NIR not only seems to have a high degree of reproducibility but may also be an optimal tool to detect longitudinal changes in body fat over time. The NIR measurement is independent of the fluid status in dialysis patients. More comparative and longitudinal studies are needed to confirm the validity of NIR measurements in longitudinal evaluation of dialysis patients.

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MALNUTRITION IN hemodialysis patients is common, and changes in nutritional variables over time occur not infrequently in this group of patients.[1-3] Longitudinal assessment of nutritional status is important because the development of protein-calorie malnutrition is a major risk factor for morbidity and mortality in dialysis patients.[4-6] Several indices of nutrition are available, ranging from the well-known anthropometric measurements[7,8] such as skin-fold thickness and midarm circumference, to subjective global assessment (SGA)[9] and its more quantitative versions.[10] However, the sensitivity of these methods in detecting early malnutrition, their practicability, and their applicability to hemodialysis patients have not been convincing.[1,2] More elaborate methods such as dual energy radiography absorptiometry and total body potassium estimates may give reliable results; however, these techniques are costly and their use is confined to a few major research centers.[11,12] A number of recent preliminary reports, including ours,[13] have advocated the use of near-infrared interactance (NIR) technology for assessment of body composition in dialysis and cardiac patients.[14,15] NIR measurement using its portable version (Futrex 5000A/ZL; Futrex Inc, Gaithersburg, MD) is a noninvasive, simple, and rapid method of assessing body fat; however, the use of NIR for longitudinal measurements has not been rigorously tested in dialysis patients. To evaluate this method further, we measured NIR and other nutritional variables in a group of dialysis patients and compared them with their corresponding repeated values after 2 months.

Methods

Patients

Our outpatient university hospital–affiliated dialysis program at San Francisco General Hospital, University of California Renal Center, served 88 adult hemodialysis patients at the time of the study. We selected those patients who have been on dialysis for at least 3 months and who agreed to participate. For the first round, 71 patients (35 men and 36 women) agreed to enroll into the study, including 3 white (nonHispanic) patients, 35 blacks, 17 Asians, and 16 Hispanic patients. Patient age ranged from 24 to 87 years (57 ± 15 years), and they had undergone dialysis from 5 months to 11 years (43 ± 30 months). For the second round 2 months later, 12 additional patients (9 men and 3 women) volunteered to be studied. None of the initial 71 patients who participated in the first round died during the interval nor did they withdraw from the second round. Hence, a total of 83 patients participated in the second round of the study. Our institutional review board approved the protocol, and written, informed consent was obtained from all participants. Further information regarding the demographic features of the patients is shown in Table 1.

Near Infra-Red

NIR is a noninvasive, simple, and rapid method of assessing percent body fat and is based on light absorption and reflection using near-infrared light emission as first described by the United States Department of Agriculture.[13,16] We used a commercially available NIR measur-

Table 1. Anthropometric and Laboratory Variables

	First Round (n = 71)	Second Round (same 71 patients)	Paired *t* Test-Based Difference	Paired *t* Test (*P* Value)	Within-Person CV (%)	Pearson *r* in All 71 Patients	Pearson *r* in 51 Patients With Stable Weight
NIR body fat (%)	28.5 ± 8.0	28.8 ± 7.7	0.2 ± 1.2	.10	5.2	0.96	0.96
Biceps skin fold (mm)	8.4 ± 6.2	10.9 ± 7.5	2.5 ± 4.6	.09	38.3	0.79	0.80
Triceps skin fold (mm)	13.1 ± 8.9	15.3 ± 10.7	2.3 ± 6.1	.08	32.1	0.83	0.83
MAC (cm)	26.5 ± 5.0	26.9 ± 4.7	0.4 ± 1.6	.09	4.4	0.95	0.94
Weight (kg)	69.1 ± 21.5	69.5 ± 21.8	1.0 ± 4.2	.09	2.2	0.99	0.99
BMI (kg/m^2)	25.0 ± 6.4	25.1 ± 6.5	0.2 ± 0.8	.08	2.2	0.99	0.99
SGA	2.0 ± 0.7	1.9 ± 0.7	0.1 ± 0.7	.52	25.9	0.48	0.44
Albumin (g/dL)	3.9 ± 0.4	3.8 ± 0.4	0.0 ± 4	.83	5.9	0.66	0.61
Transferrin (mg/dL)	161.0 ± 30.1	159.1 ± 36.5	1.3 ± 28.1	.69	12.4	0.70	0.64
TIBC (mg/dL)	178.9 ± 31.0	180.0 ± 36.8	2.3 ± 24.0	.40	9.6	0.71	0.77
Ferritin (ng/mL)	899 ± 533	826 ± 472	23 ± 332	.54	26.1	0.80	0.83
Cholesterol (mg/dL)	164.0 ± 30.2	165.2 ± 33.7	1.1 ± 21.1	.42	9.1	0.77	0.82
Creatinine (mg/dL)	10.5 ± 3.1	10.5 ± 3.1	0.1 ± 1.9	.64	7.9	0.92	0.93

Note. Mean ± SD for 2 measurements, 9 weeks apart, among 71 hemodialysis patients, as well as paired *t* test, between-group CV, and Pearson's correlation coefficients (*r*) between first and second measurements. Within-person differences are based on paired *t* test. The last column indicates correlation coefficients *r* between only those 51 patients whose weight change was less than 2 kg within the 9-week period of time.

Abbreviation: TIBC, total iron binding capacity.

ing device, Futrex 5000A/ZL, which is a portable, 900 g, 12 × 24 × 5.5 cm minicomputer, with an NIR measurement estimating range between 2.5% and 50.0% (percent of body fat).[17] The minicomputer is connected, via a light cable, to a microphone-size NIR-emitting sensor. The sensor window is equipped with a light shield before placing it on the mid upper arm to ensure that no external light interferes with the estimation of percent body fat.[13] Only several seconds are required to enter patient's data including sex, weight, height, and body frame (small, medium, large), as well as physical activity levels, into the NIR computer. Subsequently, the NIR measurement is performed while the sensor is placed on the arm for a few seconds. After the NIR sensor has measured the amount of optical interactance of the subcutaneous fat layers twice, the minicomputer calculates the total body fat on the basis of the following 6-term regression equation[17]:

$$\%Fat = K_0 + K_1 * OD_1 + K_2 * OD_2 + K_3 * Ht + K_4 * Wt + K_5 * (F.I.T.) + K_6 * sex,$$

where OD (optical density) is the negative logarithm of the amount of infrared as measured using optical interactance of the fat content underneath the skin. The NIR measurement of the fat content is based on the assumption that the concentration of any chemical constituent (including fat) is proportional to the "optical absorption" of that constituent as it pertains to near infra-red spectrum.[14] The Futrex computer takes the difference between 2 ODs into account to eliminate the influence of how hard one presses on the skin with the optical standard. Other equation elements include: Wt, weight in pounds divided by 100; Ht, height in inches divided by 100; F, exercise frequency; I, exercise intensity; T, exercise duration of time; and K_0 through K_6, term coefficients. The gender (Sex) is 1 for female and 0 for male. Futrex regression equation does not use "body frame" in the calculation of percent body fat but uses it as a variable for calculating body water according to a United States Department of Agriculture equation.[17]

In our study, NIR measurement was done by placing the Futrex 5000 sensor on the nonaccess upper arm of each dialysis patient for a few seconds after the individual data were logged into the computer. As described previously, Futrex 5000 regression equation has an additional term for physical activity data (F.I.T.), which is based on the subjective information provided by the tested individuals. The newer generations of NIR computers do not require this information. Because in this study the more commonly used NIR computer (Futrex 5000) was used, whose regression equation includes the physical activity term, we decided to nullify the effect of physical activity information on the NIR-based calculated body fat. Hence, for all patients, identical physical activity data (level 2 of frequency, intensity, and length of exercise, corresponding to light physical activity) were entered into the NIR computer. Patients were sitting in their dialysis chairs during the NIR measurement, and no exercise was performed while being tested. Body frame (small, medium, and large) was conveniently estimated by placing the thumb and index fingers around the wrist of the other hand and noticing the presence or absence of finger overlap as described in the manual.[17] All measurements were performed between 5 and 15 minutes after the termination of a dialysis session. During the second round, 14 selected patients underwent extra NIR measurements before the initiation of dialysis with their projected dry weight as the weight that entered into the NIR calculation. Other patients underwent only one measurement during each cross-sectional round.

Anthropometric Measurements

Body dry weight and skin fold measurements were performed between 5 and 15 minutes immediately after termination of the dialysis session.[13] Biceps skin fold and triceps skin fold were measured with the same conventional skin fold caliper during both rounds. Midarm circumference (MAC) was measured with a conventional tape measure. All skin fold measurements were repeated 3 times on the nonaccess arm of each dialysis patient before NIR measurements, and the average number of the 3 measurements was registered as the final result. During both rounds, all above measurements were performed by one physician who had previous experience in anthropometric measurements. Body mass index (BMI) was calculated as the ratio between end dialysis body weight (kg) and the square of height (m).[13]

Subjective Global Assessment

The SGA was used to assess overall nutritional status of all patients.[9,18] The assessment is based on the history and physical examination as described by Detsky et al.[19] The history consists of 5 criteria and focuses on weight loss in the preceding 6 months, gastrointestinal symptoms, dietary food intake, functional capacity, and comorbidities. Each of these features is scored separately in terms of A (normal or well-nourished), B (partially abnormal or moderately malnourished), or C (extremely abnormal or severely malnourished). The physical examination includes 2 items that focus on loss of subcutaneous fat over the triceps and midaxillary line of the lateral chest wall, and muscle wasting in the deltoids and quadriceps. These features are classified as: 0 = normal, 1 = mild, 2 = moderate, and 3 = severe. The data are weighted, and the patients are then classified in terms of 3 major SGA scores: A = well nourished, B = moderate malnutrition, or C = severe malnutrition. Details on the SGA for use in dialysis patients are available in the website of the American Journal of Kidney Diseases (http://www.ajkdjournal.org/abs31_2/ScoreSheet.htm) as the appendix to our recently published manuscript.[18] For ease in interpretation, the SGA scale was reversed so that a lower score represents a poorer nutrition. Hence, for this study, the SGA was scored as 3, 2, and 1 to replace A, B, and C, respectively.

Laboratory Evaluation

The laboratory variables were measured on all patients immediately before the dialysis session. Serum albumin, cholesterol, transferrin, and total iron binding capacity values were obtained by automated methods. The serum ferritin value was measured by an immunoradiometric assay with polyclonal reagents.[20] All laboratory data were measured by Spectra Laboratories, Fremont, CA.

Statistics

We used Pearson's correlation *r* for analysis of association among paired variables in each cross-sectional round. Spearman rank correlation coefficients were also obtained for nonparametric variables such as gender and SGA, and the results were compared with their corresponding Pearson's coefficients. Shapiro-Wilk analysis evaluated the normal distribution of the continuous variables. Paired *t* test analysis for repeated measurements was used to compare the longitudinal changes in 71 dialysis patients after an interval of 9 weeks. Analysis of variance (ANOVA) was used to calculate within-person coefficient of variation (CV) for the 2 measurements 2 months apart. Consistency and reproducibility were represented by ANOVA-based CV and Pearson's *r* of the measurements of the same variables after the 2-month interval. Descriptive statistics and regression analyses were carried out with a statistical software (Statistica for Windows, Release 5.1; Statsoft, Inc, Tulsa, OK). Confidence limits are given as mean ± SD. A *P* value of <.05 was accepted as statistically significant, whereas a *P* value between .05 and .10 was marginally significant.

Results

Table 1 is a summary of data for all patients between first and second cross-sectional rounds. During the first round, patients' NIR-measured body fat percentage was 28.5% ± 8.0%, and during the second round, very similar results were obtained. The paired *t* test based *P* values for NIR, anthropometric indices, BMI, and postdialysis dry weight are all between .08 and .10, denoting the development of marginally significant longitudinal changes in these measurements after the 9-week interval, whereas the *P* values for laboratory indices are all greater than .40, indicating that laboratory values including albumin and transferrin were unable to distinguish any longitudinal changes after such a short interval. The within-person CV was 5.2%. The correlation coefficient *r* between NIR measurements of the 2 rounds was 0.96 on the same 71 patients. This denotes a high degree of consistency and reproducibility of the NIR results despite the 2-month interval (Fig 1). Among all other anthropometric variables, MAC had a slightly lower CV (4.4%) and similar consistency correlations. The CVs for biceps and triceps skin fold measurements were inappropriately large (38.2% and 32.1%, respectively), denoting large variation of skin fold measurements within each round. The consistency correlation coefficients between 2 measurement rounds for biceps and triceps skin folds were 0.79 and 0.83, respectively. These lower coefficients indicate that skin fold measurements are less reliable anthropometric values in terms of reproducibility, precision, and consis-

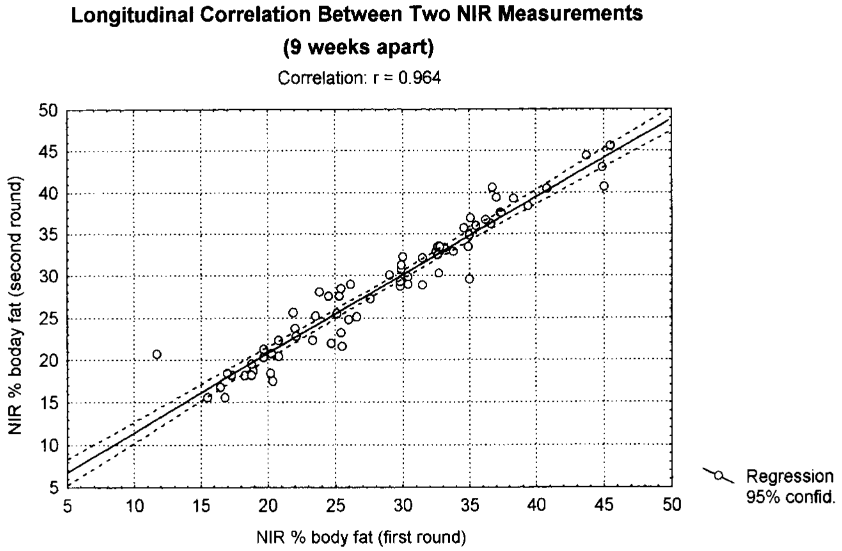

Figure 1. Pearson's correlation coefficient between first and second NIR measurements on 71 hemodialysis patients to denote measurement consistency and reproducibility. Second measurement was performed 9 weeks after the first one on the same 71 dialysis patients.

tency when compared with NIR and MAC. Nutritional assessment via SGA has the least reproducibility ($r = 0.48$) after the interval of 2 months, underscoring the "subjective" feature of the SGA. Among laboratory variables, serum creatinine seemed to be the most constant and reproducible value over time ($r = 0.92$). Serum albumin had the lowest Pearson's coefficient ($r = 0.66$) but the smallest within-person coefficient of variation (5.9%), denoting that despite large albumin variations "between" the rounds, it was able to capture changes that were not caused by within-individual variation. After deleting all 20 patients whose weight change was more than 2 kg, the Pearson's r were recalculated on all remaining 51 weight-stable patients (last column, Table 1). The correlation coefficients r were similar for NIR and other variables denoting the consistency of NIR values within a subgroup of patients with the least change in their weights.

Table 2 shows the Pearson's correlation coefficients among the different measures. NIR-measured body fat has very strong correlations with biceps and triceps skin fold ($r = 0.77$ to 0.82) and a somewhat strong correlation with MAC. The BMI has a strong correlation with NIR as well ($r = 0.73$), but the correlation coefficients between the SGA and NIR during the first and second rounds were only 0.35 and 0.55, respectively. The Spearman's rank coefficients for SGA were similar to their corresponding Pearson's r. Among laboratory variables, only serum cholesterol and creatinine concentrations seem to correlate with NIR marginally (r between 0.22 and 0.30). Compared with NIR, skin fold measurements and MAC had similar correlations with

Table 2. Cross-Sectional Pearson's Correlation Coefficients

	NIR	SGA	Biceps	Triceps	MAC	BMI
SGA	.35†/.55†					
Biceps	.82†/.77†	.44†/.45†				
Triceps	.81†/.77†	.40†/.42†	.88†/.81†			
MAC	.56†/.59†	.50†/.49†	.73†/.75†	.68†/.67†		
BMI	.73†/.73†	.49†/.54†	.78†/.73†	.71†/.63†	.83†/.82†	
Albumin	.01/.07	.30†/.27*	.00/.18	.01/.10	.09/.07	.03/.08
TIBC	.05/.11	.26*/.27*	.05/.07	.01/.11	.16/.17	.13/.12
Transferrin	.01/.16	.26*/.32†	.08/.13	.04/.13	.18/.19	.15/.18
Cholesterol	.22*/.29*	.03/.06	.22*/.28*	.27*/.29*	.17/.21	.17/.20
Creatinine	.22*/.30*	.14/.07	.11/.10	.17/.22	.21/.19	.08/.02

Note. Each cell includes 2 correlation coefficients (r_2/r_1) referring to second and first measurement rounds, 9 weeks apart, on 83 and 71 hemodialysis patients, respectively.

Abbreviation: TIBC, total iron binding capacity.

*P value between .05 and .01.

†P value <.01.

Table 3. Correlation Coefficients Among the Longitudinal Changes

Longitudinal Changes of the Values	NIR	SGA	Biceps	Triceps	MAC	BMI
SGA index	0.39†					
Biceps skin fold	0.29†	0.03				
Triceps skin fold	0.25*	0.20	0.45†			
MAC	0.29†	0.10	0.22	0.15		
BMI	0.14	0.07	0.31†	0.18	0.04	
Albumin	0.24*	0.22	0.04	0.05	0.15	0.06
Transferrin	0.36†	0.28*	0.11	0.11	0.08	0.00
TIBC	0.33†	0.36†	0.08	0.11	0.14	0.03
Cholesterol	0.18	0.01	0.13	0.15	0.19	0.34†

Note. Differences between first and second measurements that were 2 months apart. Both measurements were performed on the same 71 dialysis patients.
Abbreviation: TIBC, total iron binding capacity.
*P value between .05 and .01.
†P value <.01.

other variables. On the other hand, the SGA had modest correlations with all anthropometric measurements and some significant but weaker correlations with laboratory values.

Table 3 signifies the correlations between changes over time among pertinent values. For all 71 patients, the "longitudinal change" was defined as the value of each variable during the second round subtracted by its corresponding value in the first round. Despite having a relatively short interval of 8 to 9 weeks and, hence, frequently similar results between the 2 rounds, the longitudinal changes in NIR-measured body fat showed significant correlation with corresponding changes in biceps and triceps skin folds and MAC (r = 0.29, 0.25, and 0.29, respectively). Moreover, the changes in SGA index had significant correlation with SGA (r = 0.39) denoting that those patients who appeared to be more malnourished and obtained higher SGA scores during the second round showed decreased body fat during the same interval. Furthermore, the changes in nutritionally relevant laboratory variables including albumin, transferrin, and total iron binding capacity also showed significant correlation with longitudinal changes of NIR (r = 0.24, 0.36, and 0.33, respectively). This indicates that body fat changes measured by NIR may be able to correctly detect the corresponding changes in albumin and transferrin, the 2 important laboratory values that have significant bearing on clinical outcome of dialysis patients. The longitudinal change in SGA was the only variable that showed a similar correlation with the above-mentioned nutritional laboratory variables.

Table 4 compares 2 different modalities of NIR measurement in 14 randomly selected dialysis patients, ie, predialysis versus postdialysis measurements. Paired t test based difference between the 2 measurements is 0.1% ± 0.2% with a P value of .26. Although all patients underwent postdialysis NIR measurement, which was performed 5 to 15 minutes after the completion of dialysis session, on the above-mentioned 14 patients, an additional NIR measurement was obtained 5 to 20 minutes before the initiation of dialysis treatment of the following session, ie, 48 to 72 hours after the first NIR measurement. During the predialysis NIR measurement, the last dry weight was entered as the patient's current weight into the NIR computer. According to the data of Table 4, it seems that the timing of the NIR measurement has almost no impact on the NIR results, and the difference between the 2

Table 4. Descriptive Data Analysis of Predialysis and Postdialysis NIR-Measured Body Fat Percentages and Their Differences in 14 Selected Hemodialysis Patients

	Mean	Standard Deviation	Median	Minimum	Maximum	Correlation Coefficient
Postdialysis NIR (%)	30.09	9.68	31.90	15.60	44.40	0.999
Predialysis NIR (%)	30.18	9.70	31.85	15.70	44.70	
Difference	0.09	0.22	0.15	−0.4	0.4	

Note. Paired t test difference between 2 measurements is 0.1% ± 0.2% with a P value of .21.

NIR measurement of each patient was in the range of −0.4% to +0.4% only. This finding confirms not only the strong degree of reproducibility of the NIR measurement, but also the NIR independence of fluid status of the dialysis patients.

Discussion

We have shown that NIR measurement, a quick and convenient method to measure body fat, not only correlates well with the anthropometric measurements within each cross-sectional period of time (Table 2), but also is strongly reproducible and has robust consistency over time (Table 1). In addition to such high reproducibility, the NIR also reflected longitudinal changes of body fat, in that it had statistically significant correlations with corresponding changes in anthropometric and laboratory variables (Table 3). Another advantage of NIR we found in our study was that it was resistant to the effect of volume change in dialysis patients. Therefore, NIR measurement gave the same result whether it was done predialytically or postdialytically. Although our findings are preliminary, we believe that NIR is a promising method for longitudinal assessment of nutritional status in dialysis patients.

The NIR technology is based on the principles of light absorption and reflection using near-infrared spectroscopy, and its historical development has been explained elsewhere.[13,14] In this study, we used a commercially available NIR device (Futrex 5000), which contains a portable computer and is easily available in the United States and most European countries at a reasonable price similar to that of a bioelectrical impedance analysis.[13] The NIR commercial version is specifically designed to estimate body fat percentage on the basis of NIR measurements of the upper arm after entering a few pieces of information about the patient. The required individual data include patient's gender, weight, height, body frame (small, medium, and large), and physical activity indices (frequency, intensity, duration) and are used by the NIR computer in a regression equation model. To remove the effect of the subjective information on a patient's physical activity, we used identical information for the levels of activity for all patients. Therefore, the measured body fat in this study is solely a function of measured NIR after controlling for gender, weight, and height, but without being adjusted for subjective data about physical activity levels. Moreover, in addition to body fat, the NIR minicomputer calculates lean body mass and total body water, which can conveniently be used for the further evaluation of dialysis patients. Above all, NIR measurement is fairly quick and requires the placement of the NIR sensor on an exposed upper arm for only a few seconds, while the patient is sitting up in a dialysis chair during the dialysis session or immediately after the completion of the dialysis treatment. This contrasts with bioelectrical impedance analysis, which requires that the patient be in a supine position with electrodes on exposed feet and arms. Moreover, bioelectrical impedance is a strict function of body water and therefore should be measured at least 20 to 30 minutes after the termination of the dialysis session,[11] whereas we have shown that the NIR measurement is independent of the body water volume and, hence, can be measured at any time during the dialysis.

The reliability of NIR in determining body composition is supported by earlier studies in which the high degree of the reproducibility of NIR measurement was appreciated by performing repeated measures within short periods of time.[14,15,21,22] Elia et al[14] found a highly significant correlation between NIR and body composition as measured by whole-body densitometry, although they concluded that NIR might underestimate body fat in very obese subjects. Young et al[23] compared several body composition assessment methods to evaluate their accuracy for patients with cardiac disease for the purpose of outcome measurement and reported that NIR presented the best standard error of estimates (3.5%) and the best correlation (r = 0.84) with hydrostatic weighing. Vehrs et al[24] compared NIR with bioelectrical impedance analysis and showed that both tools underestimated hydrostatically determined percent body fat, but the standard error of the estimate and total error terms provided by regression analysis for NIR (4.6% and 5.31% body fat, respectively) were better than those for bioelectrical impedance analysis (5.65% and 6.95% body fat, respectively).

Several earlier studies applied NIR to measure body fat and body water in dialysis patients.[25-28] Soreide et al[27] used NIR to show an increase in total body fat during peritoneal dialysis. Svarstad et al[28] observed significantly different NIR scores between peritoneal and hemodialysis patients and concluded that NIR could serve to detect time-dependent differential changes in body composition. Kaufmann et al[29] used NIR, along with anthropometric and biochemical variables, to investigate the impact of long-term hemodialysis on nutritional status. In a recent preliminary report, we found that NIR had good correlation with SGA and other anthropometric and laboratory variables.[13] In that study, however, the NIR measures were found to have good correlations with albumin and transferrin, whereas in our current study, we failed to show such cross-sectional correlations. The previous study had a very limited sample size and was done in a suburban dialysis unit containing mostly white dialysis patients,[13] whereas in the current study, black, Asian, and Hispanic patients predominate, the sample size is almost doubled, and all measures are repeated twice. Nevertheless, despite the lack of correlation between NIR and laboratory values in our current study, the NIR change over time had a significant correlation with corresponding changes in serum albumin and transferrin concentration, indicating that a decrease in NIR-measured body fat is significantly correlated with a decrease in serum albumin and transferrin values over the same period of time. Similar longitudinal correlations were found between NIR and most anthropometric variables in our study.

We found that, compared with the NIR, the skinfold measurements were less precise and reproducible because they showed larger degrees of within-person coefficient of variation and lower than expected change in longitudinal correlations between the study periods. The skin fold CVs were particularly large, which may indicate a low degree of reproducibility of these measurements after 2 months of interval even though the same evaluator performed the test. Nevertheless, the possibility that the 2-month gap had something to do with this finding should be taken into consideration as well, given the fact that other relevant measurements also found corresponding changes and an identical direction (Tables 2 and 3). MAC showed a high between-round correlation and even lower coefficient of variation in our study (Table 1). However, the correlations between MAC changes over time and all other anthropometric and laboratory changes were rather weak and statistically not significant (Table 3). The SGA had modest cross-sectional correlations (Table 2), but its changes over time did not have a significant correlation with anthropometric values (Table 3). Therefore, in our study, the NIR is the only highly reproducible variable that is not only well correlated with most pertinent variables at any give period of time, but its changes have also the highest correlation with changes in other variables over time. Moreover, the NIR measurement is an easy task that can be done within several seconds and is independent of body water changes. These features underscore the indication of NIR as the most practical and reliable tool for longitudinal evaluation of nutrition in dialysis patients. Based on the results of this study, we suggest that NIR measurement be obtained every 3 to 6 months on all dialysis patients. Patients who show an unintentional, constant decrease in their NIR deserve special attention.

The NIR-measured body fat provides an extremely user-friendly and reliable nutritional assessment tool, whose measurement can be obtained within only a few seconds while the patient is attending regular dialysis treatment. We believe that the NIR can efficiently replace other nutritional methods including the more cumbersome and less precise anthropometric measurements and the more elaborate but less patient-friendly tools such as bioelectrical impedance or dual exchange radiography absorptiometry. However, the NIR validity needs to be further evaluated through more elaborate comparative and longitudinal studies.

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