Published in final edited form as:
Res Nurs Health. 2013 June ; 36(3): 284–298. doi:10.1002/nur.21539.

Using a Mobile Application to Self-Monitor Diet and Fluid Intake among Adults Receiving Hemodialysis

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Abstract

Hemodialysis patients have difficulty self-managing a complex dietary and fluid regimen. The purpose of this feasibility study was to pilot test an electronic self-monitoring intervention based on social cognitive theory. During a six-week intervention, 24 participants self-monitored diet and fluid intake using the Dietary Intake Monitoring Application (DIMA), and 20 participants served as controls by monitoring their activity using the Daily Activity Monitor Application (DAMA). Results from this pilot study suggest the intervention is feasible and acceptable, although few significant effects on outcomes were found in this small sample. The DIMA has potential to facilitate dietary and fluid self-monitoring but requires additional refinement and further testing.

Keywords

Adherence; Renal dialysis; Self-care; Computers/technology

Implementing a complex dietary and fluid prescription is challenging for the 383,000 Americans who have end-stage renal disease (ESRD) and are receiving hemodialysis (HD) (Logan, Pelletier-Hibbert, & Hodgins, 2006; United States Renal Data System, 2012). The typical daily dietary prescription for outpatient HD is 1 liter of fluid, 2 g of sodium, 2 g of potassium, and 1 g of phosphorus (Fouque, 2007). Also prescribed are a protein intake of 1.2

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g per kg of body weight per day and a dietary energy intake of 35 kilocalories per kg of body weight per day (Fouque, 2007).

Nurses collaborate with dieticians to facilitate dietary and fluid prescription self-management using educational materials that include brochures, fact sheets, lists of foods to avoid, referral to Internet sites, and ongoing counseling. Despite these efforts, patients continue to exhibit poor dietary adherence (Denhaerynck et al., 2007). To facilitate dietary and fluid self-management in daily living, nurses and other health professionals are challenged to make information available at a time convenient for patients; provide information tailored to individual needs, cultures, and food preferences; and complement patient decision-making with useful feedback. The Dietary Intake Monitoring Application (DIMA), based on mobile technology to facilitate self-monitoring, was developed to meet these challenges.

DIMA provides real-time feedback for recognizing personal intake performance and providing information for future goal-setting, both of which are elements of Bandura's Social Cognitive Theory (Bandura, 1986). Bandura (1986) also proposed that changes in behavior occur through (a) perceived ability to execute a behavior, or self-efficacy; (b) perceived benefits, or expectations that engaging in a behavior will lead to a beneficial outcome; and (c) perceived control, or the belief that a specific behavior can be shaped and influenced. This pilot study, based on Social Cognitive Theory, was conducted to examine the feasibility of using DIMA with ESRD patients with the intent to use the findings to design a randomized trial with sufficient power to assess an intervention effect. The specific purposes of this study were to explore (a) changes in interdialytic weight gain (IWG) and (b) changes in self-efficacy, perceived benefits, and perceived control in DIMA users compared to a control group. Patterns of dietary and fluid intake and acceptability of DIMA after six weeks of daily usage also were explored.

Adherence and HD Patient Outcomes

Adherence to fluid restriction is difficult for individuals receiving HD, with reported rates of adherence ranging from 25.4% to 79.5% (Kim & Evangelista, 2010; Kugler, Vlaminck, Haverich, & Maes, 2005). Actual fluid intake is indirectly measured in clinical practice and research by calculating weight gain between dialysis sessions, or IWG. An individual with an IWG of 1 kg per day is considered to be fluid-adherent (Russell et al., 2011). Limiting fluid intake reduces the risk of volume overload between dialysis treatments, but the desire to drink is a common self-reported reason for nonadherence (Kim & Evangelista, 2010). Nonadherence can result in complications such as exacerbated hypertension (Inrig et al., 2007), left ventricular hypertrophy (Velasco et al., 2012), impaired cognitive functioning (Dogukan et al., 2009), increased risk for hospitalization (Kim, Evangelista, Phillips, Pavlish, & Kopple, 2010), and increased mortality (Movilli et al.,2007; Wizemann et al., 2009).

Adherence to the dietary prescription is also difficult for individuals on HD, with reported adherence rates ranging from 18.6% to 68.2% (Kim & Evangelista, 2010; Kugler et al., 2005). Dietary intake and adherence are indirectly assessed by serum values, although the values are influenced by confounding factors such as prescribed medications or the solution used during the HD procedure. Dietary sodium must be limited because increases lead to more drinking in an effort to maintain normal serum sodium levels (Keen & Gotch, 2007). Excessive intake of potassium is associated with cardiac dysrhythmias and death (Genovesi et al., 2009). A diet high in phosphorus contributes to renal osteodystrophy, a common problem in individuals receiving dialysis (Martin & Gonzalez, 2011). Low-protein diet, low caloric intake, and decreased body mass are associated with increased mortality (Antunes et al., 2010; Rambod et al., 2009).

Variables Associated with Adherence

Empirical evidence about influences on adherence is limited in the ESRD population. Self-efficacy, conceptually defined in this context as the perceived ability to self-manage the prescribed diet and fluid regimen, has been linked to increased diet or fluid adherence or to decreased IWG (Ghaddar, Shamseddeedn, & Elzein, 2009; Lindberg & Fernandes, 2010; Lindberg, Wikstrom, & Lindberg, 2010; Tsay, 2003). More perceived benefits, conceptualized in this study as expectations that implementing the diet and fluid prescription will lead to positive outcomes, have been associated with greater diet and fluid adherence (Ghaddar et al., 2009; Walsh & Lehane, 2011). Higher levels of perceived control, conceptually defined in this study as the ability to self-regulate diet and fluid intake, have been associated with better diet and fluid intake adherence (Cvengros, Christensen, & Lawton, 2004). Lower health literacy has been associated with poorer health outcomes (Berkman, Sheridan, Halpern, & Crotty, 2011), but the effect of low health literacy on adherence in the ESRD population is unknown.

Self-Management with Mobile Technology

Self-management is the ability to “manage the symptoms, treatment, physical, psychosocial, cultural, and spiritual consequences and inherent lifestyle changes required for living with a long-term chronic disease” (Wilkinson & Whitehead, 2008, p.1145-1146). Self-monitoring, defined as awareness and recording of information that varies with daily routines (Wilde & Garvin, 2007), is one aspect of self-management (Richard & Shea, 2011). The ability of individuals receiving outpatient HD to self-monitor the daily diet and fluid regimen is often hampered by incomplete food labels, inadequate information, and poor numerical literacy skills (Abdel-Kader et al., 2010; Welch et al., 2010). Interventions are needed to overcome these barriers to self-management.

Mobile technology can be a useful tool for self-managing a chronic illness. Investigators have used Short Message Service (SMS or text messaging) to assist persons with diabetes to log blood glucose levels and to deliver educational information or personalized messages (Cole-Lewis & Kershaw, 2010; Cooper, Cooper, & Milton, 2009; Fjeldsoe, Marshall, & Miller., 2009; Krishna & Boren, 2008). The SMS interventions, however, require reading and comprehension skills that may limit their usefulness. In addition, SMS logging has not been paired with a mechanism to enable participants to view their own aggregate data, so they have not received performance information to aid in altering behavior.

In other studies, individuals with diabetes have used mobile phones to photograph their dietary intake and then reflect on the images along with contextual information (Arsand, Tufano, Ralston & Hjortdahl, 2008; Smith, Frost, Albayrak, & Sudhakar, 2007). Despite the usefulness of reflection in dietary practices (Arsand et al., 2008; Smith et al., 2007), some participants voiced concern about the time needed to take before-and-after photographs of their food (Arsand et al., 2008). Other researchers (Six et al., 2010) found adolescents had difficulty capturing food photos that included a common object as a point of reference to determine portion size. Importantly, photographing food cannot provide the real-time feedback needed for decision-making about actual food intake (Arsand et al., 2008).

Some researchers have explored the use of off-the-shelf, nutrition-monitoring personal digital assistant (PDA) applications to assist people with ESRD. In one study, three individuals receiving HD used a PDA to self-monitor dietary intake but had difficulty finding food items and navigating the device (Welch, Dowell, & Johnson, 2007). Stark and

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colleagues (2011) reported relatively high self-monitoring rates in two pilot studies in which individuals were receiving either HD or peritoneal dialysis. Over a 16-week intervention period, those receiving HD entered 73% of expected meals, and those receiving peritoneal dialysis entered 63% of expected meals.

These findings suggest that electronic dietary intake self-monitoring has potential for persons receiving HD, although studies with large samples and strong designs are needed. Previous interventions have required high reading or comprehension skills, did not provide real-time feedback about intake, and were relatively cumbersome and hard to navigate. DIMA was designed to avoid these problems.

Pilot testing of DIMA is needed before determining the efficacy of this intervention in a larger sample. Specific hypotheses for this pilot study were that in comparison to a control group who used a PDA-based electronic Daily Activity Monitoring Application (DAMA), HD patients who self-monitored dietary and fluid intake using the DIMA PDA application would: (a) have greater reductions in IWG at the end of and at 8 weeks following self-monitoring; (b) show improving adherence to the dietary and fluid regimen over the course of the intervention period; (c) have increases in self-efficacy, perceived benefits, and perceived control compared to controls at the end of and at 8 weeks following self-monitoring; and (d) rate DIMA as an acceptable intervention at the end of the self-monitoring.

Methods

DIMA Intervention

DIMA is an electronic dietary self-monitoring application for use on a personal digital assistant (PDA). Bandura’s social cognitive theory (Bandura, 1986) and health literacy literature guided the design of the DIMA. It provides individualized, ongoing information to assist patients with dietary and fluid self-monitoring.

DIMA was developed with two self-contained databases: a nutrition database and a Universal Product Code (UPC) database. Participants could scan food packages with UPCs using the attached UPC scanner or select icons for foods that did not have a UPC. A feedback screen displayed participants’ intake in relation to their dietary prescriptions, thus facilitating awareness of performance attainment, the most influential source of efficacy information. Because DIMA automatically computed totals, patients did not need to read food labels or make mathematical computations (Welch et al., 2010). More information on its design for use by individuals with low literacy has been reported elsewhere (Chaudry, Connelly, Siek, & Welch, 2012; Connelly et al., 2012; Welch et al., 2010).

Participant training for DIMA use took about 2 hours over 2-3 dialysis sessions. Training included use of the home screen; navigation through the application; use of icons, UPC scanner, and voice-recorder to enter dietary and fluid intake data; use of the feedback screens; and selecting portion sizes. Participants used DIMA for one week following training to become familiar with the application before beginning the 6-week self-monitoring period. Research assistants (RAs) provided additional training, as needed, during the week following the planned training. After the one-week practice period, participants in the DIMA group were considered competent users when they could correctly enter three practice meals and several types of drinks and snacks. A 24-hour telephone number was provided in case participants had questions or problems with the application at home. RAs met with participants at each dialysis session to download the intake data during the intervention period.

Control Group

Participants in the control group were assigned to the Daily Activity Monitoring Application (DAMA), an electronic application for PDAs designed for this study. The use of DAMA ensured that the amount of time spent with participants during the intervention phase was similar to the time spent with participants in the DIMA group. The control group was instructed to self-monitor activity in 8 categories (walking, biking, weight lifting, shopping, yard work, child care, housework, and cooking). Participants selected icons representing activities they performed and then selected the appropriate clock icon to indicate the amount of time spent in these activities. Participants could view their daily total amount of time in each activity.

DAMA participants were trained to use the intervention in about 30 minutes at one dialysis session. Training included using the PDA home screen, navigating through the application, selecting an activity, and entering time spent with the activity. Similar to those using DIMA, participants used DAMA for one week following the training to become familiar with the application, with follow-up training by RAs if needed, before beginning self-monitoring. All participants assigned to DAMA were assessed as being competent in its use when they could correctly enter practice activities and time. A 24-hour telephone number was provided for questions or problems with the application at home. RAs met with participants at each dialysis session to download the intake data during the intervention period.

Recruitment and Sample

After approval was obtained from the institutional review board, dialysis unit staff distributed introductory letters to individuals receiving treatment at two urban outpatient dialysis units. In these letters, potential participants were provided a toll-free telephone number to call if they did not wish to be contacted by a research team member. Approximately one week later, during hemodialysis treatment, a RA contacted those potential participants who did not call and explained the study, determined interest in participating, obtained written informed consent, and obtained written authorization for the release of health information.

Individuals were eligible if they: (a) were 18 years of age or older, (b) were alert and oriented, (c) were able to read and converse in English, (d) were currently receiving outpatient HD as their primary treatment modality, (e) had been on HD for 3 months or longer, (f) were willing to use technology, and (g) self-reported difficulty following at least one aspect of their dietary and fluid prescription. Individuals were excluded if they (a) were living in an assisted- or extended-care facility, (b) were receiving outpatient HD on a temporary basis following a peritoneal dialysis complication or an episode of transplant rejection, (c) reported having no intent to comply with dietary or fluid restrictions, or (d) were receiving home HD.

From a pool of 220 dialysis patients, 89 individuals (40%) agreed to be assessed for eligibility. Of these, 14 did not meet eligibility criteria and 31 declined to participate. Figure 1 illustrates the flow of participants throughout the study.

The study sample of 44 participants ranged in age from 23 to 80 years ($M = 50.3$, SD 13.8) and were 57% male ($n = 25$), 82% African American ($n = 36$), and 73% unmarried ($n = 32$). Years of education ranged from 9 to 20 ($M = 12.9$; $SD = 2.2$); length of time receiving treatment for ESRD ranged from 6 months to 13.8 years ($M = 4.4$ years; SD 3.7 years). Hypertension was the predominant cause of ESRD (36.4%), followed by type II diabetes (31.8%). The two participating sites were operated by the same organization, and sample characteristics were representative of individuals treated at these sites. For example, of the 220 people treated at these sites, 84% were African American and 54% were male. There were no statistically significant differences in age or gender between the participants and nonparticipants. A greater percentage of African American and biracial subjects than Caucasians ($p < .05$) agreed to participate in the study.

Group Assignment

Within one week of completing baseline data collection, 23 participants were randomized to the intervention group and 21 to the control group. Randomization was blocked and stratified by dialysis unit. After assigning participants to groups, we learned that one person in the control group had limited ability to engage in activities due to a leg amputation; that person was re-assigned to the intervention group. The reassignment resulted in 24 participants (54.5%) in the intervention and 20 (45.4%) in the attention control group.

As shown in Figure 1, of the 24 participants in the DIMA Group, five did not receive the intervention and three discontinued the intervention. All participants in the control group received the DAMA intervention but three discontinued the intervention before the end of the intervention period. Thus, there was an overall attrition rate of 25% by the end of the 8-week follow-up. There were no statistically significant differences in age, gender, race, dialysis unit, or group between those who continued in the study and those who did not.

Procedures

The RAs were graduate students or undergraduate students in their senior year and had backgrounds in public health or computer science; one RA had a doctoral degree. The RA training was conducted by the project manager and included data collection, hands-on training with the computer and PDA, procedures for uploading data, and recruitment procedures with role playing and practice using a recruitment script. The RAs were required to demonstrate competence in: (a) all study procedures, (b) using the DIMA and DAMA applications, and (c) dealing with technical difficulties that might be encountered with the computer or PDA applications. The RA training was supplemented with a training manual. The project manager regularly visited the clinic sites to assure the RAs remained competent and were compliant with all study procedures, and to address any concerns or questions the RAs might have.

Data collection for individuals in the intervention and control groups occurred at study entry (baseline), the end of the 6-week self-monitoring period, and 8 weeks following self-monitoring (14 weeks after baseline). Participant data were collected by RAs during HD treatment. The RAs read questionnaire items for baseline and follow-up data collections to each participant, who responded verbally to each item. The RAs recorded responses in a secure computer database. Pre- and post-dialysis weights were collected for the 3 weeks preceding baseline data collection and continued throughout the study on each HD day. The DIMA group collected PDA data on dietary patterns (sodium, potassium, phosphorus, protein, and calories) and fluid intake that were downloaded at each dialysis session. Usage logs for both groups showing the date and time of data entry were also downloaded during each dialysis session.

Measures

Actual interdialytic weight gain (IWG)—Participants were weighed pre- and post-dialysis as parts of routine clinical care using an electronic scale calibrated prior to each weighing. IWG was calculated by subtracting the previous post-dialysis weight from the current pre-dialysis weight. This number was divided by the number of days between treatments to arrive at a daily weight gain. Previous researchers have used different time intervals when calculating IWG; for example, IWG has been based on mean daily weight

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gain over 1, 2, 3, and 12 weeks (Welch & Thomas-Hawkins, 2005). In this study, the daily average of IWG from one treatment to the next showed the least within-group variability.

Self-efficacy—Self-efficacy was assessed using two instruments. The Cardiac Diet Self-Efficacy Instrument (Hickey, Owen, & Froman, 1992) was used to measure diet self-efficacy. The original 16-item scale had a Cronbach's alpha of .90, test-retest reliability of .86, known-groups construct validity with marathon runners (t = 4.58, p < .001), and concurrent validity as illustrated by a positive relationship between diet self-efficacy and diet goal attainment (r = .62, p < .001) among individuals participating in cardiac rehabilitation (Hickey et al., 1992).

In this study, the 16-item scale was modified to reflect the renal diet. For example, we changed "staying on a healthy diet when I eat in a restaurant" to "staying on the renal diet when I eat in a restaurant." We also added four items to capture the complexity of the renal diet. For example, we added the item "decreasing the amount of potassium in my diet." Content validity of the modified instrument was assessed by two experts in nephrology nursing and two experts in nephrology nutrition. Participants responses to each item could range from 1 (*not at all confident*) to 4 (*very confident*). Responses were summed, with higher scores indicating greater diet self-efficacy. Scores could range from 20 to 80. Cronbach's alphas in this study ranged from .89 - .93 across the three data collection points.

The 11-item Fluid Self-Efficacy Scale (FSES) was used to measure fluid self-efficacy. Participants responded to each item from 1 (*strongly disagree*) to 5 (*strongly agree*). Evidence of content validity was obtained from expert nephrology nurses and dieticians and internal consistency reliability (alphas .80 to .84) has been documented in individuals receiving outpatient HD (Welch, 2001; Welch et al., 2003). Responses were summed, with higher scores reflecting greater fluid self-efficacy. Scores could range from 11 to 55. Cronbach's alpha in this study ranged from .81 to .85 across the three data collection points.

Perceived benefits—Benefits were assessed using two instruments. Benefits of Sodium Adherence (BSA) was used to measure perceived benefits related to dietary sodium adherence. The BSA is a 7-item scale originally designed for use in persons with heart failure (Bennett, Milgrom, Champion, & Huster, 1997; Bennett et al., 2001) and modified for use in persons receiving HD (Welch, Bennett, Delp, & Agarwal, 2006). Evidence of content validity was obtained from two expert renal dieticians. Internal consistency reliability (alpha = .74), and test-retest reliability (r = .68) have 'been reported (Welch et al., 2006). Participants' responses to each item could range from 1 (*strongly disagree*) to 5 (*strongly agree*). Responses were summed, with higher numbers reflecting greater perceived benefits. Scores could range from 7 to 35. In this study, Cronbach's alphas ranged from .82 - .91 across the three data collection points. It is unclear why the alpha coefficients were higher in this much smaller sample of participants compared to earlier reports.

The 9-item Benefits of Fluid Adherence scale was used to measure perceived benefits of fluid adherence. This measure was pilot-tested in HD patients (Welch, 2001). Content validity was assessed by three experienced master's-prepared nephrology nurses. Participants are asked to respond to each item on a scale from 1 (*strongly disagree*) to 5 (*strongly agree*). Responses were summed, with higher numbers reflecting greater perceived benefits. Scores could range from 9 to 45. Internal consistency reliability coefficients have been low in past research, ranging between .71 and .78 (Welch, 2001; Welch et al., 2003). The individual items in the Benefits of Fluid Adherence scale reflect a wide variety of physical benefits that may not be related; for example, a relationship between muscle cramping and hospitalization would not be expected. Thus, it is not surprising that the scale had low internal consistency in past research. Cronbach's alphas were higher in this study, ranging from .79 - .91 across all data collection points, although the reasons for this improvement are not clear.

Perceived control—Perceived control was assessed using a 7-item mastery scale (Pearlin & Schooler, 1978). Participants rated items on 5-point scales from 1 (*strongly disagree*) to 5 (*strongly agree*). Responses were summed, with higher numbers reflecting greater perceived control. Scores could range from 7 to 35. Cronbach's alpha was low at .75 in past research among stroke survivors (Kim & Kim, 2008), possibly due to the small number of items comprising the scale. Cronbach's alphas were slightly higher in this study, ranging from .78 - .82 across the three data collection points.

Diet and fluid intake—RAs downloaded the automatically calculated daily sodium, potassium, phosphorus, protein, calorie, and fluid intake based on patient-recorded food items from DIMA into a computer database during each dialysis session. We summed weekly intake and then divided the total by the number of days for which entries were made.

Acceptability—DIMA acceptability was assessed by a 25-item questionnaire developed by Rawl and colleagues (unpublished report) and modified for this study. Participants rated the items on 5-point response scales from 1 (*strongly disagree*) to 5 (*strongly agree*). Mean scores were computed, with higher scores indicating greater acceptability.

Acceptability was also assessed by calculating from the application log files the number of days participants used the application during the self-monitoring period. We omitted days of known illness or PDA malfunction. Usage rates were computed by dividing the number of days an entry was made by the total days of self-monitoring and multiplying by 100. Participants were considered active users if they used DIMA at least 50% of the time during the study. We chose a cut point of 50% because 75% of the participants met this criteria.

Demographic and clinical data—Age, education, gender, race, and marital status were self-reported by participants. We collected the ESRD start date and the cause of chronic kidney failure from the dialysis record to more fully describe our sample.

Data Analysis

Responses to questionnaire items and electronic data were entered into a secure computer database and transferred to a secure server for statistical analysis using SAS. Descriptive statistics were used for all measures. Baseline data were compared between those assigned to intervention and control groups using *t* tests for continuous variables and chi-square or Fisher's exact tests for categorical variables.

To explore our first hypothesis, linear mixed models were fit to explore IWG over time and between groups. Treatment group was entered in all models as a fixed effect and patient as a random effect. To determine the optimal time period for calculating the dependent measure, we did a sensitivity analysis of five approaches: visit (baseline, 6 weeks of self-monitoring, 8 weeks after self-monitoring), dialysis dates, and weekly, bi-weekly, and monthly intervals. The standard error of the treatment effect was calculated for each model. The treatment-by-time interaction term was tested in all models. Quadratic trends were tested and found non-significant in all models. Trends over time were also explored by graphing IWG over time in the two treatment groups. At Week 6, a two-sample *t* test comparing mean weekly IWG levels between intervention and control groups was also performed.

To address our second hypothesis, mean dietary and fluid intake were computed for each DIMA subject at baseline and at Week 6. Paired *t* tests were performed to compare these means within the DIMA group.

To address the third hypothesis, linear mixed model analyses were used to explore changes in self-efficacy, perceived benefits, and perceived control. The models included fixed effects for treatment group (intervention vs. control) and time (baseline, after 6 weeks of treatment, and 8 weeks after treatment) and a treatment-by-time interaction. When the treatment-by-time interaction was significant, separate post hoc tests were done comparing the two treatment groups at each time point. For all linear mixed models, residuals were checked for normality and plotted against time. No violations of model assumptions were identified. Because this was a feasibility study, no adjustments for multiple comparisons were done.

To address the fourth hypothesis, descriptive scale statistics were computed to describe the acceptability of DIMA among the intervention participants.

Results

There were 24 subjects assigned to the intervention group (DIMA) and 20 to the control group (DAMA). As shown in Table 1, there were no differences between the two groups in any of the key study variables at baseline.

Interdialytic Weight Gain

Participants were, on average, adherent to fluid restriction at baseline as indirectly assessed by IWG. The standard error of the treatment effect was almost identical across all time periods (range 0.14 to 0.18); therefore, results based on IWG as determined at every dialysis session are presented. Because there was a significant treatment-by-time interaction ($p < 0.01$), the analyses were done separately by period (baseline, 6 weeks of self-monitoring, 8 weeks after self-monitoring).

There was no effect of group assignment on IWG during the baseline or post-self-monitoring periods ($p = 0.37$ and $p = 0.40$, respectively). As shown in Figure 2, there was a strong trend for relatively lower IWG levels in DIMA patients during the 6 weeks of self-monitoring ($p = 0.06$). Results remained unchanged when less active users were removed from the analysis (treatment-by-time interaction $p = 0.06$, treatment group $p = 0.46$ during the baseline period, $p = 0.07$ during the self-monitoring period, and $p = 0.24$ during the post-self-monitoring period).

In a two-sample *t* test at week 6, mean (*SD*) IWGs in the intervention and control groups were 0.81 (0.48) and 1.00 (0.62), respectively ($p = 0.22$). A paired *t* test, comparing IWG at baseline to Week 6, was conducted using only DIMA patients. The mean difference (baseline minus Week 6; $M = 0.13$; $SD = 0.33$) was not significantly different ($p = .12$). When less active users were removed these analyses, the results were similar.

Dietary Intake in the DIMA Group

We compared dietary intake at week 6 with that of week 1 for participants in the intervention group only. As shown in Table 2, there was a marginal decrease in calories across all patients ($p = 0.09$). Active users had a decrease in sodium intake ($p = 0.05$) and calories ($p = 0.04$), as well as a marginal decrease in protein ($p = 0.08$).

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Self-Efficacy, Perceived Benefits, and Perceived Control

There were no differences between groups or over time in perceived benefits or self-efficacy. As shown in Table 3, however, there was a significant group difference in perceived control over time (treatment-by-time interaction, $p = 0.01$). The intervention and control groups were similar at baseline ($p = .51$), but at the end of self-monitoring, the intervention group had higher perceived control than control group ($p = .01$). The two groups were similar again 8 weeks after the self-monitoring period ($p = .55$). With active users only, as shown in Table 4, the results were similar.

Acceptability of DIMA

On the scale of 1-5, the mean acceptability score in the DIMA group was 3.93 (*SD* = 0.43, Median = 3.86, range 2.68–4.68). Items ranked more favorably were (a) satisfied using the monitor for my food and diet intake (*M* = 4.33), (b) easy to use (*M* = 4.28), and (c) feedback was helpful (*M* = 4.28). Items ranked less favorably included (a) needed more information than provided (*M* = 3.33), (b) the scanner was helpful (*M* = 3.44), and (c) easily found find the icons needed (*M* = 3.61).

During the self-monitoring period, DIMA use ranged from 2 to 48 days. The monitoring period went beyond the scheduled 42 days in some participants due to dialysis scheduling, an illness, or PDA problems. Five participants (26.4%) used the application on less than half the number of days available, and 5 (26.4%) used it more than 80% of the time.

Discussion

We obtained preliminary data about the effects of a mobile application on IWG, patterns of dietary and fluid intake, self-efficacy, perceived control, and perceived benefits among HD patients. We also obtained data on the acceptability of the application to users. The main findings from this study were that DIMA was a feasible and acceptable intervention that had a marginal effect on some aspects of dietary and fluid intake. DIMA needs further refinement to increase usage before being tested in a larger study.

Potential participants were required to self-report difficulty with at least one component of the renal diet (fluid, sodium, potassium, phosphorus, protein, or caloric intake) to be included in the study. The only outcome variable we measured was IWG as an indirect indicator of fluid intake. Although there was a trend for weight gain to decrease somewhat during the study, IWG was at recommended and acceptable levels at baseline. This was surprising because the literature indicated that 25 - 80% individuals receiving HD have difficulty maintaining a safe and appropriate IWG (Kim & Evangelista, 2010; Kugler et al., 2005). Individuals who were not adherent to fluid restriction may have simply declined to participate. The intervention also may have been short to produce changes in outcomes.

For this feasibility study, we excluded other outcome measures a priori, including serum albumin, potassium, and phosphorus, as well as pre-dialysis blood pressure. Other factors could have confounded the outcomes, such as medications and the dialysate used during the HD procedure. In retrospect, these measures might have provided important data and should be included in future work.

Perceived benefits of sodium and fluid adherence did not change in the pilot study. This finding was unexpected. Although we know of no intervention that has been tested in the HD population to improve perceived benefits, in one study using theory-based Web instruction on hip fracture prevention among older adults, outcome expectations (benefits) for calcium intake were significantly increased ($p < .01$) immediately after a 2-week intervention and at a 3-month follow-up (Nahm et al., 2010). Perhaps our finding was

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observed because IWG was in the recommended range at baseline, and participants may not have perceived additional benefits to their well-being.

There were no statistically significant improvements in dietary or fluid self-efficacy, although there was a trend toward greater fluid self-efficacy among participants who used the application more often. Jerant, Moore-Hill, and Franks (2009) found that when compared to phone training or usual care, an in-home self-management training program improved self-efficacy in 415 chronically ill adults in 6 weeks, and the changes were sustained 6 months later; changes were not sustained at one year. These findings suggest self-efficacy might improve if DIMA was used more. The trend for improved self-efficacy in those who used the application more often was consistent with the theoretical assertion that performance attainment is an influential source of efficacy information.

Perceived control increased in the DIMA group but returned to baseline by the end of the follow-up interval, suggesting the need for booster interventions. More marked improvements in perceived control over time might have been seen if the intervention dose had been higher.

Although participants did not record their entire intake, there were nonsignificant trends for decreased intake of fluids, sodium, potassium, and phosphorus over the 6 weeks of self-monitoring among all participants. In participants who used DIMA 50% of the time, however, there was a significant reduction of sodium intake. A concerning trend was the reduction in protein and caloric intake over the self-monitoring interval, providing further impetus to add other outcome data to the next phase of intervention testing.

The overall attrition rate was 25% in this feasibility study. Although we planned for this attrition rate, we expected most of our attrition to occur due to a change in condition, change in treatment modality, or the complexity and length of the study. As shown in Figure 1, however, five participants in the DIMA intervention were lost prior to beginning the intervention, and of these, one was unable to learn the application. Some attrition may be preventable in future studies by modifying the inclusion criteria, such as setting required levels of visual acuity or health literacy. Of the six participants who discontinued their assigned intervention during the monitoring, only one (in the control group) did so because of a desire to discontinue participation, suggesting an electronic intervention may have been acceptable to participants.

The use of an electronic intervention has the advantage of allowing the dose of an intervention to be examined. In past research, regular collection of self-monitoring data has improved compliance with monitoring (Stetson et al., 2011). Although we met with participants during each dialysis session, participants did not enter intake as instructed. Perhaps if we had sampled only those individuals new to dialysis, the intervention may have had more appeal and they would have been more engaged. Alternatively, additional technological features may be important when self-monitoring intake among individuals receiving HD (Chaudry et al., 2012; Welch et al., 2010). Proposed revisions, such as context-driven reminders or visual cues, are reported elsewhere (Connelly et al., 2012). Involving future users in focus groups as DIMA is revised may help us gain insight into additional features that would help them incorporate the application into daily living. In addition, including participants from suburban and/or rural facilities may help us determine if there are any cultural issues that affect usage.

This feasibility study was limited by inadequate power due to the small sample size, possible error in our measures, the lack of direct self-efficacy statements to participants in the DIMA group, and the potential for interactions among participants in the intervention and control groups while in the dialysis setting. This study was also limited by our selection of two urban dialysis units that served individuals who were predominantly African American and not new to dialysis. Qualitative data to explore the experience of using technology for self-monitoring may have also provided information to improve use of DIMA in daily living. Attention to these limitations before conducting a larger randomized controlled trial is recommended.

Conclusion

Adults receiving HD have difficulty implementing the complex, restrictive dietary and fluid regimen in daily living. The results of this study provide direction for continued intervention development and testing to help people undergoing HD follow the recommended dietary and fluid plans. We learned that we must find ways to increase intervention usage. In addition, modifications to the inclusion criteria and outcome variables must be made. Data from this feasibility study will be used to inform the development of future intervention studies designed to facilitate effective self-monitoring of adherence to the prescribed dietary and fluid intake regimen among adults receiving hemodialysis.

Acknowledgments

This research was supported by grants from NIH/National Institute of Biomedical Imaging and Bioengineering (R21EB007083), a T32 Postdoctoral Training Grant (NIH T32 NR007066), and Indiana University School of Nursing Research Investment Funds.

References

Abdel-Kader K, Dew MA, Bhatnagar M, Argyropoulos C, Karpov I, Switzer G, Unruh ML. Numeracy skills in CKD: Correlates and outcomes. Clinical Journal of the American Society of Nephrology. 2010; 5:1566–1573. doi:10.2215/CJN.08121109. [PubMed: 20507954]

Antunes AA, Delatim Vannini F, de Arruda Silveria LV, Martin LC, Barretti P, Caramori JC. Influence of protein intake and muscle mass on survival in chronic dialysis patients. Renal Failure. 2010; 32:1055–1059. [PubMed: 20863209]

Arsand E, Tufano J, Ralston J, Hjortdahl P. Designing mobile dietary management support technologies for people with diabetes. Journal of Telemedicine and Telecare. 2008; 14:329–332. [PubMed: 18852310]

Bandura, A. Social foundations of thought and action: A social cognitive theory. Prentice Hall; Englewood Cliffs, NJ: 1986.

Bennett SJ, Milgrom LB, Champion V, Huster GA. Beliefs about medication and dietary compliance in people with heart failure: An instrument development study. Heart & Lung. 1997; 26:273–279. [PubMed: 9257137]

Bennett SJ, Perkins SM, Lane KA, Forthofer MA, Brater C, Murray MD. Reliability and validity of the compliance belief scales among patients with heart failure. Heart & Lung. 2001; 30:177–185. doi:10.1067/mhl.2001.114193. [PubMed: 11343003]

Berkman ND, Sheridan SL, Donahue KE, Halpern DJ, Crotty K. Low health literacy and health outcomes: An updated systematic review. Annals of Internal Medicine. 2011; 155:97–107. [PubMed: 21768583]

Chaudry B, Connelly KH, Siek KA, Welch JL. Formative evaluation of mobile liquid portion size estimation interface for people with varying literacy skills. Journal of Ambient Intelligence and Humanized Computing. 2012 Advance online publication. doi:10.1007/s12652-012-0152-9.

Cole-Lewis H, Kershaw T. Text messaging as a tool for behavior change in disease prevention and management. Epidemiologic Reviews. 2010; 32(1):56–69. [PubMed: 20354039]

Connelly K, Siek K, Chaudry B, Jones J, Astroth K, Welch JL. An offline mobile nutrition monitoring intervention for varying literacy patients receiving hemodialysis: A pilot study examining usage and usability. Journal of the American Medical Informatics Association. 2012; 19:705–712. doi: 10.1136/amiajnl-2011-000732. [PubMed: 22582206]

Cooper H, Cooper J, Milton B. Technology-based approaches to patient education for young people living with diabetes: A systematic literature review. Pediatric Diabetes. 2009; 10:474–483. [PubMed: 19490492]

Cvengros JA, Christensen AJ, Lawton WJ. The role of perceived control and preference for control in adherence to a chronic medical regimen. Annals of Behavioral Medicine. 2004; 27:155–161. doi: 10/1207/s15324796abm2703_3. [PubMed: 15184091]

Denhaerynck K, Manhaeve D, Dobbels F, Garzoni D, Nolte C, De Geest S. Prevalence and consequences of nonadherence to hemodialysis regimens. American Journal of Critical Care. 2007; 16:222–235. [PubMed: 17460313]

Dogukan A, Guler M, Yavuzkir MF, Tekatas A, Poyrazoglu OK, Aygen B, Yoidas TK. The effect of strict volume control on cognitive functions in chronic hemodialysis patients. Renal Failure. 2009; 31:641–646. doi:10.3109/08860220903134548. [PubMed: 19814630]

Fjeldsoe BS, Marshall AL, Miller YD. Behavior change interventions delivered by mobile telephone short-message service. American Journal of Preventive Medicine. 2009; 36:165–173. [PubMed: 19135907]

Fouque D, Vennegoor M, ter Wee P, Wanner C, Basci A, Canaud B, VanHolder R. EBPG guideline on nutrition. Nephrology Dialysis Transplantation. 2007; 22(Suppl 2):ii45–ii87. doi: 10.1093/ndt/gfm020.

Ghaddar S, Shamseddeen W, Elzein H. Behavioral modeling to guide adherence to fluid control in hemodialysis patients. Journal of Renal Nutrition. 2009; 19:153–160. [PubMed: 19218042]

Genovesi S, Valsecchi MG, Rossi E, Pogliani D, Acquistapace I, De Cristofaro V, Vincenti A. Sudden death and associated factors in a historical cohort of chronic haemodialysis patients. Nephrology Dialysis Transplantation. 2009; 24:2529–2536.

Hickey ML, Owen SV, Froman RD. Instrument development: Cardiac diet and exercise self-efficacy. Nursing Research. 1992; 41:347–381. [PubMed: 1437584]

Inrig JK, Patel UD, Gillespie BS, Hasselblad V, Himmelfarb J, Reddan D, Szczech LA. Relationship between interdialytic weight gain and blood pressure among prevalent hemodialysis patients. American Journal of Kidney Diseases. 2007; 50:108–118. doi:10.1053/j.ajkd.2007.04.020. [PubMed: 17591530]

Jerant A, Moore-Hill M, Franks P. Home-based, peer-led chronic illness self-management training: Findings from a 1-year randomized controlled trial. Annals of Family Medicine. 2009; 7:319–327. doi:10.1370/afm.996. [PubMed: 19597169]

Keen ML, Gotch FA. The association of the sodium “set-point” to interdialytic weight gain and blood pressure in hemodialysis patients. International Journal of Artificial Organs. 2007; 30:971–979. [PubMed: 18067098]

Kim Y, Evangelista LS. Relationship between illness perceptions, treatment adherence, and clinical outcomes in patients on maintenance hemodialysis. Nephrology Nursing Journal. 2010; 37:271–280. [PubMed: 20629465]

Kim Y, Evangelista LS, Phillips LR, Pavlish C, Kopple JD. The end-stage renal disease adherence questionnaire (ESRD-AQ): Testing the psychometric properties in patients receiving in-center hemodialysis. Nephrology Nursing Journal. 2010; 37:377–393. [PubMed: 20830945]

Kim JH, Kim O. Influence of mastery and sexual frequency on depression in Korean men after a stroke. Journal of Psychosomatic Research. 2008; 65:565–569. [PubMed: 19027446]

Krishna S, Boren SA. Diabetes self-management care via cell phone: A systematic review. Journal of Diabetes Science & Technology. 2008; 2:509–517. [PubMed: 19885219]

Kugler C, Vlaminck H, Haverich A, Maes B. Nonadherence with diet and fluid restrictions among adults having hemodialysis. Journal of Nursing Scholarship. 2005; 37:25–29. doi:10.1111/j.1547-5069.2005.00009.x. [PubMed: 15813583]

Lindberg M, Fernandez MAE. Self-efficacy in relation to limited fluid intake amongst Portuguese hemodialysis patients. Journal of Renal Care. 2010; 36:133–138. [PubMed: 20690965]

Lindberg M, Wikstrom B, Lindberg P. Subgroups of haemodialysis patients in relation to fluid intake restrictions: A cluster analytical approach. Journal of Clinical Nursing. 2010; 19:2997–3005. doi: 10.1111/j.1365-2702.2010.03372.x. [PubMed: 21040006]

Logan SM, Pelletier-Hibbert M, Hodgins M. Stressors and coping of in-hospital haemodialysis patients aged 65 years and over. Journal of Advanced Nursing. 2006; 56:382–391. [PubMed: 17042818]

Martin KJ, Gonzalez EA. Prevention and control of phosphate retention/hyperphosphatemia in CKD-MBD: What is normal, when to start, and how to treat? Clinical Journal of the American Society of Nephrology. 2011; 6:440–446. [PubMed: 21292848]

Movilli E, Gaggia P, Zubani R, Camerini C, Vizzardi V, Parrinello G, Cancarini G. Association between high ultrafiltration rates and mortality in uraemic patients on regular haemodialysis: A 5-year prospective observational multicentre study. Nephrology Dialysis Transplantation. 2007; 22:223547–3552. doi:10.1093/ndt/gfm466.

Nahm E, Barker B, Resnick B, Covington B, Magaziner J, Brennan P. Effects of a social cognitive theory-based hip fracture prevention Web site for older adults. CIN: Computers, Informatics, Nursing. 2010; 28:371–379. doi:10.1097/NCN.0b013e3181f69d73.

Pearlin LI, Schooler C. The structure of coping. Journal of Health & Social Behavior. 1978; 19:2–21. [PubMed: 649936]

Rambod M, Bross R, Zitterkoph J, Benner D, Pithia J, Colman S, Kalantar-Zadeh K. Association of malnutrition-inflammation score with quality of life and mortality in hemodialysis patients: A 5-year prospective cohort study. American Journal of Kidney Diseases. 2009; 53:298–309. doi: 10.1053/j.ajkd.2008.09.018. [PubMed: 19070949]

Richard AA, Shea K. Delineation of self-care and associated concepts. Journal of Nursing Scholarship. 2011; 43:255–264. [PubMed: 21884371]

Russell CL, Cronk NJ, Herron M, Knowles N, Matteson ML, Peace L, Ponferrada L. Motivational interviewing in Dialysis Adherence Study (MIDAS). Nephrology Nursing Journal. 2011; 38:229–236. [PubMed: 21877456]

Six BL, Schap TE, Zhu FM, Mariappan A, Bosch M, Delp EJ, Boushey CJ. Evidence-based development of a mobile telephone food record. Journal of the American Dietetic Association. 2010; 110:74–79. [PubMed: 20102830]

Smith BK, Frost J, Albayrak M, Sudhakar R. Integrating glucometers and digital photography as experience capture tools to enhance patient understanding and communication of diabetes self-management practices. Personal and Ubiquitous Computing. 2007; 11:273–286. doi: http://dx.doi.org/10.1007/s00779-006-0087-2.

Stark S, Snetselaar L, Piraino B, Stone RA, Kim S, Hall B, Sevick MA. Personal digital assistant-based self-monitoring adherence rates in 2 dialysis dietary intervention pilot studies: BalanceWise-HD and BalanceWise-PD. Journal of Renal Nutrition. 2011; 21:492–498. [PubMed: 21420316]

Stetson B, Schlundt D, Peyrot M, Ciechanowski P, Austin MM, Young-Hyman D, Sherr D. Monitoring in diabetes self-management: Issues and recommendations for improvement. Population Health Management. 2011; 14:189–197. doi:10.1089/pop.2010.0030. [PubMed: 21323462]

Tsay SL. Self-efficacy training for patients with end-stage renal disease. Journal of Advanced Nursing. 2003; 43:370–375. doi:10.1046/j.1365-2648.2003.02725.x. [PubMed: 12887355]

United States Renal Data System. 2012 USRDS Annual data report: Atlas of chronic kidney disease and end stage renal disease in the United States. National Institutes of Health, National Institute of Diabetes and Digestive and Kidney Diseases; Bethesda, MD: 2012.

Velasco N, Chamney P, Wabel P, Moissl U, Imtiaz T, Spalding E, McGregor M, Innes A, MacKay I, Patel R, Jardine A. Optimal fluid control can normalize cardiovascular risk markers and limit left ventricular hypertrophy in thrice weekly dialysis patients. Hemodialysis International. 2012; 16:465–472. doi: 10.1111/j.1542-4758.2012.00689.x. [PubMed: 22515643]

Walsh E, Lehane E. An exploration of the relationship between adherence with dietary sodium restrictions and health beliefs regarding these restrictions in Irish patients receiving haemodialysis for end-stage renal disease. Journal of Clinical Nursing. 2011; 20:331–340. doi:10.1111/j.1365-2702.2010.03348. [PubMed: 21219516]

Welch JL. Hemodialysis patient beliefs by stage of fluid adherence. Research in Nursing & Health. 2001; 24:105–112. doi:10.1002/nur.1013. [PubMed: 11353458]

Welch JL, Bennett SJ, Delp RL, Agarwal R. Benefits of and barriers to dietary sodium adherence. Western Journal of Nursing Research. 2006; 28:162–180. doi:10.1177/0193945905282323. [PubMed: 16513918]

Welch JL, Dowell S, Johnson CS. Feasibility of using a personal digital assistant to self-monitor diet and fluid intake: A pilot study. Nephrology Nursing Journal. 2007; 34:43–48. [PubMed: 17345691]

Welch JL, Perkins SM, Evans JD, Bajpai S. Differences in perceptions by stage of fluid adherence. Journal of Renal Nutrition. 2003; 13:275–281. doi:10.1053/S1051-2276(03)00115-8. [PubMed: 14566764]

Welch JL, Siek KA, Connelly KH, Astroth KS, McManus MW, Scott L, Kraus M. Merging health literacy with computer technology: Self-managing diet and fluid intake among adult hemodialysis patients. Patient Education and Counseling. 2010; 79:192–198. doi:10.1016/j/pec2009.08.016. [PubMed: 19796911]

Welch JL, Thomas-Hawkins C. Psycho-educational strategies to promote fluid adherence in adult hemodialysis patients: A review of intervention studies. International Journal of Nursing Studies. 2005; 42:597–608. doi:10.1016/j.ijnurstu.2004.09.015. [PubMed: 15921991]

Wilde M, Garvin S. A concept analysis of self-monitoring. Journal of Advanced Nursing. 2007; 57:339–350. doi:10.1111/j.1365-2648.2006.04089.x. [PubMed: 17233653]

Wilkinson A, Whitehead L. Evolution of the concept of self-care and implications for nurses: A literature review. International Journal of Nursing Studies. 2009; 46:1143–1147. doi:10.1016/j.inurstu.2008.12.011. [PubMed: 19200992]

Wizemann V, Wabel P, Chamney P, Zaluska W, Moissl U, Rode C, Marcelli D. The mortality risk of overhydration in haemodialysis patients. Nephrology Dialysis Transplantation. 2009; 24:1574–1579.

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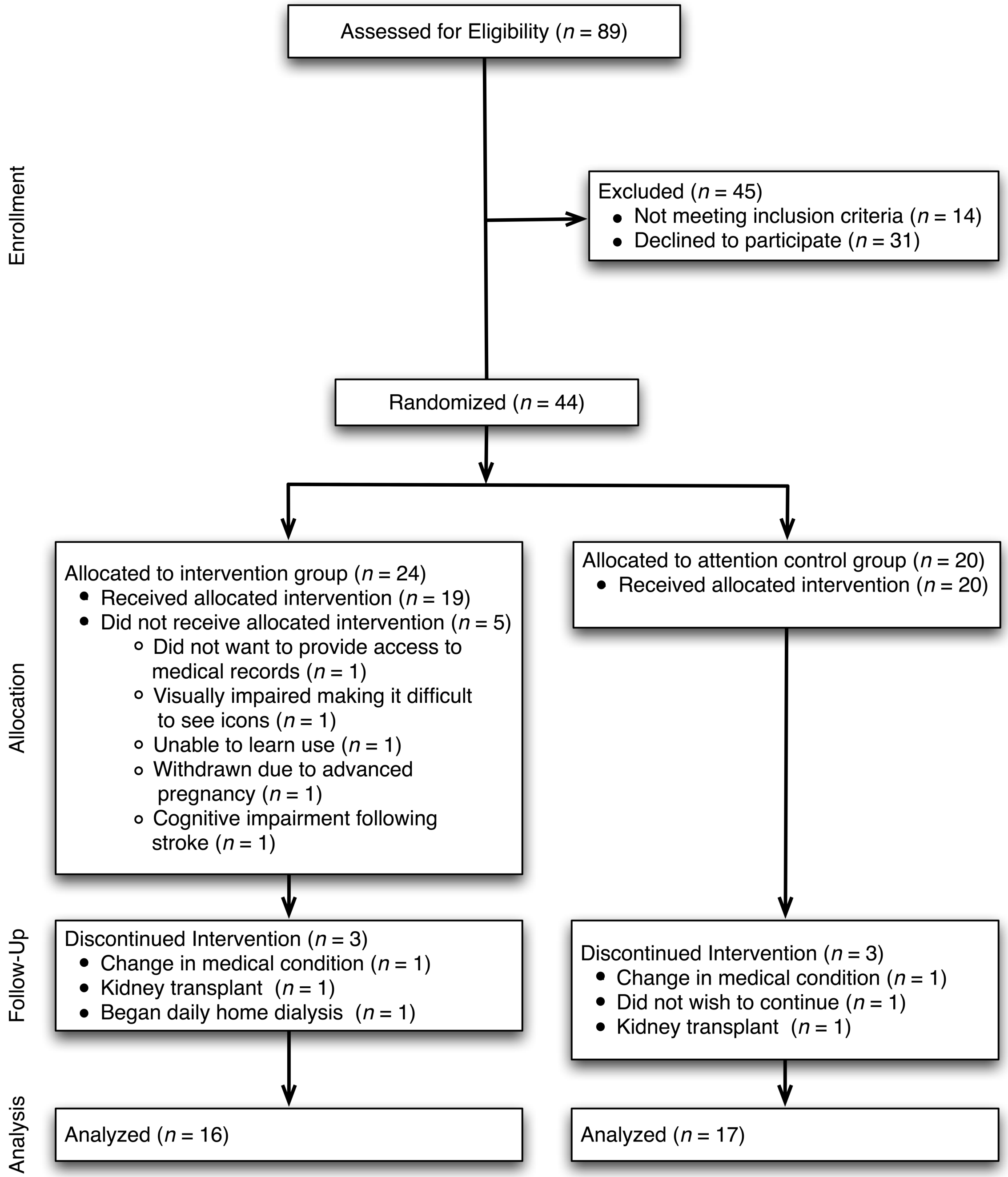

Figure 1.
CONSORT Diagram of Participant Flow

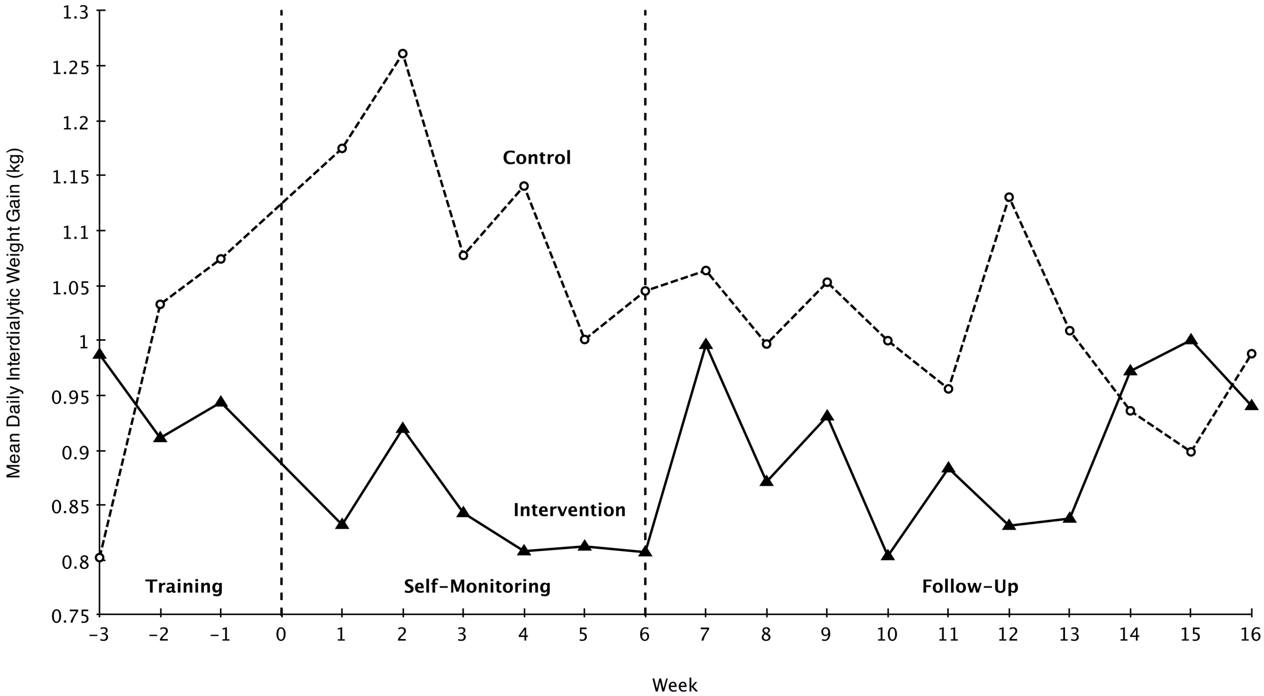

Figure 2.
Mean Daily Interdialytic Weight Gain by Week and Group

Table 1

Characteristics of Intervention and Control Subjects at Baseline

		Total Sample *N* = 44		Intervention *n* = 24		Control *n* = 20		*p*
		n		n		n		
Sex	Female	19		12		7		0.32
	Male	25		12		13		
Race	Black	36		21		15		0.39
	White	4		1		3		
	Bi-racial	3		1		2		
	Refused	1		1		0		
Dialysis unit	Site #1	19		11		8		0.70
	Site #2	25		13		12		
		M	(SD)	*M*	(SD)	*M*	(SD)	
Age		50.3	(13.8)	53.0	(15.1)	47.1	(11.5)	0.16
Interdialytic weight gain (kg per day)		1.0	(0.5)	0.9	(0.5)	1.1	(0.6)	0.45
Perceived benefits of fluid adherence		37.9	(4.7)	37.3	(4.7)	38.5	(4.6)	0.44
Perceived benefits of sodium adherence		30.5	(3.5)	30.3	(3.0)	30.7	(4.0)	0.69
Diet self-efficacy		34.9	(9.6)	35.5	(9.5)	34.2	(10.0)	0.65
Fluid self-efficacy		40.8	(6.6)	40.7	(5.6)	41.0	(7.9)	0.88
Perceived control		26.0	(5.5)	26.5	(6.1)	25.4	(4.6)	0.51

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Table 2

Comparison of Mean Fluid and Dietary Intake in the Dietary Intake Monitoring Application (DIMA) Group at Baseline and End of Self-Monitoring

	All DIMA Subjects (n = 14)					DIMA Active Users Only (n = 11)				
	Week 1		Week 6			Week 1		Week 6		
	M	***SD***	***M***	***SD***	***p***	***M***	***SD***	***M***	***SD***	***p***
Fluid ml	503.4	340.6	469.0	297.7	0.76	559.9	363.8	466.1	209.7	0.45
Sodium mg	2381.7	1751.7	1498.2	738.6	0.12	2778.7	1759.5	1434.2	618.0	0.05
Potassium mg	1592.6	1251.0	1060.2	757.5	0.16	1758.4	1322.0	989.0	542.5	0.10
Phosphorus mg	872.8	785.7	568.1	393.3	0.21	991.1	830.4	515.5	193.7	0.11
Protein g	59.7	42.1	40.6	22.7	0.18	68.0	43.3	38.2	13.2	0.08
Calories kcal	1335.6	862.1	835.7	495.8	0.09	1496.1	887.6	777.2	273.1	0.04

Note: DIMA active users were defined as those who used DIMA at least 50% of the intervention period.

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Table 3

Change over Time and Treatment Effect on Self-Efficacy, Perceived Benefits, and Perceived Control

		Baseline			End of Self-Monitoring			Eight-Week Follow-Up			Treatment-by-Time Interaction	Treatment Effect*
		n	***M***	***SD***	***n***	***M***	***SD***	***n***	***M***	***SD***	***p***	***p***
Diet self-efficacy	Intervention	23	35.5	9.5	18	32.7	10.1	16	33.2	12.4	0.52	0.40
	Control	19	34.2	10.0	17	31.1	10.2	17	28.8	6.8		
Fluid self-efficacy	Intervention	23	40.7	5.6	18	41.4	5.8	16	43.6	5.7	0.39	0.21
	Control	19	41.0	7.9	18	43.9	6.4	17	46.6	5.4		
Perceived benefits of	Intervention	23	30.3	3.0	18	29.9	4.4	16	31.6	2.8	0.59	0.77
sodium adherence	Control	20	30.7	4.0	18	30.3	4.2	17	31.0	3.8		
Perceived benefits of	Intervention	22	37.3	4.7	18	37.5	4.9	16	39.8	4.5	0.48	0.28
fluid adherence	Control	20	38.5	4.6	18	39.6	6.1	17	40.1	4.9		
Perceived Control	Intervention	23	26.5	6.1	18	28.5	4.9	16	26.6	5.2	0.01	--
	Control	20	25.4	4.6	17	23.6	4.3	17	25.1	5.2		

* when no treatment by time interaction is present ($p > 0.1$)

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Table 4

Change over Time and Treatment Effect on Self-Efficacy, Perceived Benefits, and Perceived Control (Active Users Only)

		Baseline			End of Self-Monitoring			Eight-Week Follow-Up			Treatment-by-Time Interaction	Treatment Effect*
		n	*M*	*SD*	*n*	*M*	*SD*	*n*	*M*	*SD*	*p*	*p*
Diet self-efficacy	Intervention	14	36.5	9.3	14	34.6	10.3	12	35.8	13.2	0.35	0.26
	Control	14	33.4	8.1	13	32.1	11.3	14	29.8	6.6		
Fluid self-efficacy	Intervention	14	40.5	4.8	14	41.6	5.1	12	42.5	5.9	0.17	0.25
	Control	14	40.0	8.5	14	44.2	7.2	14	47.3	5.8		
Perceived benefits of	Intervention	14	31.9	2.6	14	31.2	2.8	12	32.5	2.5	0.87	0.60
sodium adherence	Control	14	31.6	3.9	14	30.6	4.6	14	31.4	3.5		
Perceived benefits of	Intervention	14	39.7	3.3	14	38.7	3.9	12	40.1	4.7	0.31	0.59
fluid adherence	Control	14	39.1	4.7	14	40.1	6.8	14	41.5	4.1		
Perceived control	Intervention	14	26.9	5.6	14	28.7	4.5	12	27.4	3.8	0.02	--
	Control	14	25.9	4.4	13	24.3	4.8	14	25.6	5.4		

* when no treatment by time interaction is present ($p > 0.1$)