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# ESRD patients using permanent vascular access report greater physical activity compared with catheter users

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## Abstract

**Purpose—**Low levels of physical activity among end-stage renal disease (ESRD) patients are associated with increased risk of hospitalization and mortality, and contributors to low activity levels are important to identify. Among hemodialysis (HD) patients, use of a central venous catheter (CVC) might impede physical activity due to factors such as infection or patient fear of catheter dislodgement.

**Methods—**This Comprehensive Dialysis Study surveyed patients who had recently started regular dialysis. Physical activity level was ascertained using responses to the Human Activity Profile (HAP) provided by 1,458 HD participants. We examined the association of vascular access type with patients' scores on HAP subscales measuring self-care and leg effort, two dimensions that are especially important for daily living.

**Results—**32.6% of patients used an arteriovenous fistula (AVF), 11.5% used an arteriovenous graft, 51.8% used a CVC, and 4.1% used a CVC with another maturing access. Patients' self-care and leg effort scores differed by vascular access type and receipt of early nephrology care, and the mean self-care score of AVF users who received early care was similar to the mean score reported for healthy adults.

**Conclusions—**Reported levels of self-care and leg effort activity were higher among incident HD patients using an AVF compared to those using a CVC. Future research should examine whether reinforcing the importance of regular physical activity in the pre-dialysis period, as well as wider early use of AVF in the HD population, may improve physical activity levels among ESRD patients.



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**Keywords**

Dialysis vascular access; Physical function

## Introduction

End-stage renal disease (ESRD) patients report markedly low levels of physical functioning and activity [1–5]. Lower self-reported physical activity scores among ESRD patients are predictive of increased hospitalization and greater cardiovascular and all-cause mortality [6–8]. A possible contributor to reduced physical activity and physical functioning among hemodialysis (HD) patients is use of the central venous catheter (CVC), which may impede physical activity due to patient fear of catheter dislodgement, infection, or poorer dialysis clearance resulting in greater fatigue. The most recent annual report of the United States Renal Data System (USRDS) indicated that 82% of ESRD patients in the United States initiate HD with a CVC alone or a CVC with a maturing arteriovenous fistula (AVF) or graft [9]. The goal of this study was to describe self-reported physical activity levels among a national cohort of incident ESRD HD patients with different vascular access types, using the well-validated Human Activity Profile [10].

## Methods

The Comprehensive Dialysis Study (CDS) is the source of data for this analysis. The CDS is a prospective study of patients initiating dialysis within units throughout the United States between September 2005 and June 2007. Details of the study are provided elsewhere [11]. A total of 1,645 adult dialysis patients from 295 dialysis clinics within 18 ESRD Networks were surveyed, and 1,473 of whom were receiving HD. Study information and a consent form and participation availability form were sent to eligible participants. Patients who completed and returned a signed consent form were subsequently contacted to schedule a phone interview by DataBanque Research Services (Pittsburgh, PA, USA), a data management organization contracted by the CDS.

Patient physical activity level was ascertained using the Human Activity Profile (HAP) administered by telephone interview. The HAP provides a survey of activities across a broad range of energy requirements. The activity items are based on estimated metabolic equivalents, that is, the approximate amount of oxygen consumed by an average person at rest. For each item, the respondent indicates whether he or she is still doing, has stopped doing, or never did the activity.

The HAP was developed to provide a general classification of an individual’s usual and maximum activity levels. This report focuses on two HAP research subscales: (1) self-care activity, one activity dimension on which people focus their efforts, and (2) leg effort, a muscle group dimension that taps activities requiring use of the legs as the primary component. The self-care subscale assesses eight basic activities necessary for a person to live independently; the reported mean for healthy adults is 7.83. The leg effort subscale includes 50 items, and the reported overall mean for healthy adults is 41.9 [10].

Data from the USRDS Medical Evidence standard analysis file were used to determine patient age, gender, race, body mass index (BMI), diabetes, congestive heart failure (CHF), coronary artery disease (CAD), cerebrovascular disease (CVD), peripheral vascular disease (PVD), other cardiac disease, chronic obstructive pulmonary disease (COPD), smoking status, and ability to ambulate and transfer; hemoglobin concentration and serum albumin at the start of dialysis; and pre-dialysis receipt of dietitian, erythropoiesis stimulating agents

(ESAs), and nephrology care. For the latter three variables, we used the USRDS classification of <6 months prior to ESRD for pre-ESRD care that was reported but was not specified as having been received 6–12 months prior or more than 12 months prior to ESRD start. Regression analyses were performed with patient self-care and leg effort HAP scores as the outcome variables, with access type as an independent variable, adjusting for these sociodemographic, clinical, and early care variables.

## Results

### Demographic and clinical characteristics of the study cohort

Among the 1,473 HD patients who participated in the CDS, current vascular access and demographic information were available for 1,458 patients. Overall, 32.4% of these patients used an AVF, 11.5% used an arteriovenous graft (AVG), 52.1% used a CVC, and 4.0% used a catheter plus another maturing access (Table 1). While age was not significantly different across vascular access categories, patients using an AVF were more likely to be male. Members of the study cohort had similar vintage, approximately 4 months receiving dialysis (median = 122 days; mean = 129 days) [11].

Body mass index (BMI), diabetes, CHF, CAD, CVD, PVD, COPD, smoking status, and inability to transfer were not significantly different across vascular access categories. Conversely, inability to ambulate, hemoglobin concentration, and serum albumin at the start of dialysis were significantly greater among patients with an AVF, and pre-ESRD dietitian care, pre-ESRD exogenous erythropoietin (EPO) use, and pre-ESRD nephrology care received 6 months or more prior to ESRD were associated with AVF use.

Patients who used an AVF scored higher on the self-care subscale as well as on the leg effort subscale, compared to patients using a graft, catheter, or catheter with maturing AVF or graft.

### Patient-reported self-care score

Coefficient estimates were calculated for HAP self-care subscale scores, which reflect patients' ability to conduct the basic activities necessary for independent living (Table 2). Compared with patients using an AVF, those using a CVC reported a significantly lower level of self-care ($P = 0.01$), while there was no significant difference in reported self-care between patients with an AVF and AVG. With each increasing year of age, patient-reported self-care decreased significantly. Native Hawaiian or other Pacific Islander patients reported a significantly lower level of self-care compared with White patients ($P = 0.02$). Comorbid conditions associated with significantly lower self-care levels compared with patients without these disorders included PVD ($P = 0.002$), COPD ($P = 0.009$), and (as expected) inability to transfer ($P < 0.0001$). Self-care scores were higher among patients with greater levels of serum albumin at dialysis initiation ($P = 0.01$) and among patients who received dietitian care more than 12 months prior to ESRD start ($P = 0.03$).

### Patient-reported leg effort score

Table 3 shows calculated coefficient estimates for the leg effort score, reflecting use of leg muscles for daily activity, following adjustment for confounding variables. Patients using a CVC had significantly lower scores than patients using an AVF ($P = 0.008$). Like self-care, leg effort significantly decreased with each year of age ($P < 0.0001$). Males reported significantly greater leg effort than females ($P < 0.0001$). Leg effort was lower among patients with higher BMI ($P = 0.006$), diabetes ($P < 0.0001$), PVD ($P = 0.02$), COPD ($P = 0.02$), tobacco use ($P = 0.01$), inability to ambulate ($P = 0.04$), and higher hemoglobin concentration ($P = 0.01$), but reported leg effort was greater with higher serum albumin ($P < 0.0001$).

After stratifying by gender, leg effort was no longer associated with vascular access type among females in an adjusted model. In contrast, leg effort scores were significantly lower among males using a CVC ($P = 0.02$) than among males with permanent vascular access (data not shown).

### Self-care and leg effort scores in relation to nephrology pre-ESRD care

When patients were classified by receipt of early nephrology care of any duration versus no early nephrology care, mean self-care scores and mean leg effort scores differed significantly across vascular access type among patients who received early nephrology care, but not among patients who did not receive early nephrology care. Table 4 indicates that the mean self-care score of AVF users who received early care, 7.1, approached the mean score of 7.83 reported for healthy adults [10]. However, mean leg effort scores in the study cohort, with the highest being 16.8 for AVF users who received early nephrology care, were well below the mean of 41.9 reported for healthy adults (12), regardless of patients' early care receipt and vascular access type (Table 5).

## Discussion

Previous research has shown that ESRD patients report very low physical functioning and physical activity, and that self-reported scores are predictive of all-cause and cardiovascular mortality [6–8]. There is little information, however, about the relationship between physical activity/effort and HD vascular access type. We found that vascular access type was associated with differences in self-reported, self-care, and leg effort in a national sample of incident HD patients from randomly sampled dialysis facilities. Patients using permanent AV access scored highest, while those using a CVC scored lowest, despite a comparable prevalence of diabetes, cardiovascular morbidity, tobacco use, and ability to ambulate and transfer among AVF, AVG, and CVC patients in our cohort.

The frequent perception by clinicians is that CVC patients have a substantially greater burden of comorbidities, particularly cardiopulmonary disease. However, the distribution of comorbid conditions and BMI was similar among the three vascular access cohorts in our study. As a result, it is difficult to attribute the significantly lower self-reported physical activity among CVC patients to impairment from cardiopulmonary conditions.

There are several possible explanations for the association between CVC use and lower self-reported physical activity. First, patients may fear CVC dislodgement and limit physical activity, as unlike a permanent AV access, the CVC is inserted into a deep central vein within the upper chest or groin, tunneled under the skin, and sutured in place. The dual-lumen ports remain exposed and accessible to dialysis personnel. In addition, CVC use increases the risk of infection and may result in a reduced delivered dose of dialysis [12, 13]. Although reduced hours of nocturnal sleep and post-dialysis fatigue might be expected to be associated with lower activity levels, in patient-reported data, we did not find that nocturnal sleep hours or the estimated length of time needed to "recover'' following dialysis differed significantly by patients' vascular access type (data not shown).

Our analyses suggest that permanent vascular access in the form of an AVF is associated with greater patient-reported physical activity. Our study included a national, incident dialysis patient cohort that closely matched the entire population of US adult patients who initiated HD in the same time period. However, several study limitations must be noted. A patient self-report measure was used, but our observations are based on the validated HAP questionnaire that has a high correlation with physical performance measures and with physical activity measured by 7-day accelerometry [14]. In addition, there is no reason to expect that self-reported physical activity would be biased systematically based on access type. Second, as this study is observational, there is the potential for confounding by severity of illness. We minimized this bias by controlling for comorbid conditions that may influence the choice of vascular access type. However, we acknowledge that additional unmeasured variables were not accounted for in this study. Third, our findings are cross-sectional and therefore may not reflect future physical activity levels over time. Longitudinal studies are needed to determine whether changes in type of vascular access are associated with changes in level of physical activity, for example, with patients becoming more active when transitioned from a CVC to AVF. Finally, we lack data regarding dialysis adequacy, which can differ by vascular access type and may impair physical activity. Despite these limitations, our findings reflect a difference in reported self-care and leg effort activity by patients' vascular access type, extending the evidence that permanent vascular access use is associated with greater overall physical activity levels in dialysis patients [15].

Given the association of physical activity with survival, further research is needed to elucidate the primary factors limiting physical activity among dialysis patients. In addition, further research is needed to determine whether reinforcing the importance of and encouraging regular physical activity in the pre-dialysis period may improve activity levels among ESRD patients after initiation of maintenance HD therapy and whether increasing the use of AVF results in greater physical activity in this population.

## Acknowledgments

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**Table 1**

Characteristics of CDS cohort by vascular access type

| | **Fistula** (***n*** **= 473)** | **Graft** (***n*** **= 167)** | **Catheter** (***n*** **= 759)** | **Other** (***n*** **= 59)** | ***P*** **value** |
|---|---|---|---|---|---|
| Age (mean ± SD) | 61.0 ± 13.9 | 62.4 ± 14.1 | 60.4 ± 14.0 | 58.5 ± 14.5 | 0.23 |
| Male (%) | 64.5 | 45.5 | 52.4 | 55.9 | <0.0001 |
| Race (%) | | | | | 0.06 |
| White | 56.5 | 47.9 | 53.9 | 55.9 | |
| Black | 25.6 | 37.1 | 28.6 | 33.9 | |
| American Indian/Alaska Native | 1.5 | 1.8 | 0.8 | 3.4 | |
| Asian | 2.3 | 1.8 | 1.1 | 0.0 | |
| Native Hawaiian/other Pacific Islander/other race | 14.2 | 11.4 | 15.7 | 6.8 | |
| BMI (mean ± SD) | 29.6 ± 7.8 | 30.6 ± 8.9 | 30.0 ± 8.4 | 28.6 ± 6.8 | 0.30 |
| Diabetes (%) | 51.0 | 62.3 | 53.4 | 49.2 | 0.07 |
| CHF (%) | 27.7 | 35.3 | 33.5 | 39.0 | 0.07 |
| CAD (%) | 26.2 | 24.6 | 21.3 | 27.1 | 0.22 |
| CVD (%) | 8.3 | 9.0 | 7.1 | 10.2 | 0.70 |
| PVD (%) | 15.0 | 17.4 | 15.3 | 18.6 | 0.80 |
| Other cardiac disease (%) | 14.6 | 11.4 | 15.7 | 17.0 | 0.53 |
| COPD (%) | 6.8 | 11.4 | 8.3 | 8.5 | 0.31 |
| Smoker (%) | 60.9 | 59.0 | 60.3 | 71.2 | 0.39 |
| Unable to transfer (%) | 0.2 | 0.6 | 0.7 | 0.0 | 0.67 |
| Unable to ambulate (%) | 1.1 | 3.6 | 3.2 | 0.0 | 0.046 |
| Hemoglobin, g/dl (mean ± SD) | 10.2 ± 1.8 | 9.9 ± 1.7 | 9.9 ± 1.7 | 9.9 ± 1.8 | 0.01 |
| Serum albumin, g/dl (mean ± SD) | 3.3 ± 0.7 | 3.1 ± 0.7 | 3.1 ± 0.7 | 3.3 ± 0.6 | <0.0001 |
| Dietitian pre-ESRD care (%) | | | | | 0.002 |
| Not received | 80.4 | 87.1 | 90.3 | 92.6 | |
| Received <6 months prior | 3.8 | 4.1 | 2.2 | 1.9 | |
| Received 6–12 months prior | 8.6 | 4.1 | 4.5 | 3.7 | |
| Received >12 months prior | 7.2 | 4.8 | 3.0 | 1.9 | |
| EPO received pre-ESRD (%) | | | | | <0.0001 |

| | Fistula ($n$ = 473) | Graft ($n$ = 167) | Catheter ($n$ = 759) | Other ($n$ = 59) | *P* value |
|---|---|---|---|---|---|
| Not received | 46.8 | 48.3 | 65.2 | 69.8 | |
| Received <6 months prior | 10.5 | 13.6 | 7.3 | 7.6 | |
| Received 6–12 months prior | 26.4 | 22.5 | 19.7 | 18.9 | |
| Received >12 months prior | 16.4 | 15.7 | 7.8 | 3.8 | |
| Nephrology pre-ESRD care (%) | | | | | <0.0001 |
| Not received | 14.8 | 19.8 | 41.1 | 41.1 | |
| Received <6 months prior | 14.8 | 14.2 | 10.5 | 10.7 | |
| Received 6–12 months prior | 27.2 | 27.8 | 21.4 | 21.4 | |
| Received >12 months prior | 43.3 | 38.3 | 26.8 | 26.8 | |
| Self-care HAP score (mean ± SD) | 6.9 ± 1.7 | 6.5 ± 2.0 | 6.3 ± 1.9 | 6.7 ± 1.5 | <0.0001 |
| Leg effort HAP score (mean ± SD) | 16.4 ± 9.8 | 13.6 ± 9.1 | 13.4 ± 9.2 | 14.4 ± 9.4 | <0.0001 |

*BMI* body mass index, *CHF* congestive heart failure, *CAD* coronary artery disease, *CVD* cerebrovascular disease, *PVD* peripheral vascular disease, *COPD* chronic obstructive pulmonary disease, *ESRD* end-stage renal disease, *EPO* erythropoietin, *HAP* human activity profile

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## Table 2

HAP self-care score predictors from multivariable analysis

| | Coefficient estimate* | *P* value |
|---|---|---|
| Fistula (referent) | | |
| Graft | −0.09 | 0.66 |
| Catheter | −0.36 | 0.01 |
| Other | −0.12 | 0.69 |
| Age | −0.02 | 0.0008 |
| Male | 0.15 | 0.24 |
| White race (referent) | | |
| Black | −0.06 | 0.67 |
| American Indian/Alaska Native | −1.15 | 0.05 |
| Asian | −0.37 | 0.43 |
| Native Hawaiian/other Pacific Islander/other race | −0.43 | 0.02 |
| BMI | −0.008 | 0.32 |
| Diabetes | −0.16 | 0.23 |
| PVD | −0.54 | 0.002 |
| COPD | −0.60 | 0.009 |
| Smoker | −0.13 | 0.33 |
| Unable to transfer | −3.20 | <0.0001 |
| Unable to ambulate | −0.20 | 0.65 |
| Hemoglobin | −0.03 | 0.41 |
| Serum albumin | 0.23 | 0.01 |
| Dietitian pre-ESRD care | | |
| Not received | 0.68 | 0.09 |
| Received <6 months prior (referent) | | |
| Received 6–12 months prior | 0.51 | 0.19 |
| Received >12 months prior | 1.10 | 0.03 |
| Nephrology pre-ESRD care | | |
| Not received | −0.05 | 0.83 |
| Received <6 months prior (referent) | | |
| Received 6–12 months prior | 0.34 | 0.18 |
| Received >12 months prior | 0.45 | 0.07 |

*Model adjusted also for CHF, CAD, CVD, other cardiac disease, and receipt of pre-ESRD EPO ($P > 0.05$)

## Table 3

HAP leg effort score predictors from multivariable analysis

| | Coefficient estimate* | *P* value |
|---|---|---|
| Fistula (referent) | | |
| Graft | −0.73 | 0.45 |
| Catheter | −1.81 | 0.008 |
| Other | −1.75 | 0.23 |
| Age | −0.12 | <0.0001 |
| Male | 5.88 | <0.0001 |
| White race (referent) | | |
| Black | −1.16 | 0.10 |
| American Indian/Alaska Native | 1.41 | 0.62 |
| Asian | −1.23 | 0.58 |
| Native Hawaiian/other Pacific Islander/other race | −0.77 | 0.39 |
| BMI | −0.10 | 0.006 |
| Diabetes | −2.91 | <0.0001 |
| PVD | −2.04 | 0.02 |
| Other | −1.06 | 0.21 |
| COPD | −2.48 | 0.02 |
| Smoker | −1.57 | 0.01 |
| Unable to transfer | −5.36 | 0.13 |
| Unable to ambulate | −4.28 | 0.04 |
| Hemoglobin | −0.43 | 0.01 |
| Serum albumin | 1.73 | <0.0001 |
| Dietitian pre-ESRD care | | |
| Not received | 1.22 | 0.53 |
| Received <6 months prior (referent) | | |
| Received 6–12 months prior | 1.05 | 0.65 |
| Received >12 months prior | 4.51 | 0.06 |
| Nephrology pre-ESRD care | | |
| Not received | −1.36 | 0.24 |
| Received <6 months prior (referent) | | |
| Received 6–12 months prior | −1.64 | 0.18 |
| Received >12 months prior | −0.07 | 0.95 |

*Model adjusted also for CHF, CAD, CVD, other cardiac disease, and receipt of pre-ESRD EPO ($P > 0.05$)

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**Table 4**

Mean self-care score by nephrology pre-ESRD care and vascular access type

| | Fistula | Graft | Catheter | Other | *P* value |
|---|---|---|---|---|---|
| With early nephrology care | 7.1 | 6.6 | 6.4 | 7.0 | <0.0001 |
| Without early nephrology care | 6.2 | 6.3 | 6.3 | 6.2 | 0.98 |

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**Table 5**

Mean leg effort score by nephrology pre-ESRD care and vascular access type

| | **Fistula** | **Graft** | **Catheter** | **Other** | ***P* value** |
|---|---|---|---|---|---|
| With early nephrology care | 16.8 | 13.5 | 13.0 | 14.2 | <0.0001 |
| Without early nephrology care | 14.3 | 14.4 | 14.0 | 14.3 | 0.99 |