OBSERVATIONAL STUDY

Gait speed and hospitalization among ambulatory hemodialysis patients: USRDS special study data

Nancy G Kutner, Rebecca Zhang, Yijian Huang, Haimanot Wasse

Nancy G Kutner, Rebecca Zhang, Yijian Huang, USRDS Rehabilitation/Quality of Life Special Studies Center, Emory University, Atlanta, GA 30322, United States
Haimanot Wasse, Renal Division, Department of Medicine, and USRDS Rehabilitation/Quality of Life Special Studies Center, Emory University, Atlanta, GA30322, United States
Author contributions: Zhang R had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis; Kutner NG, Zhang R, Huang Y, and Wasse H contributed to study concept and design, analysis and interpretation of data, and critical revision of the manuscript for important intellectual content; Kutner NG acquired the data, obtained funding, provided administrative, technical and material support, and drafted the manuscript; Kutner NG and Wasse H provided study supervision; Zhang R and Huang Y provided statistical analysis.
Correspondence to: Nancy G Kutner, PhD, Department of Rehabilitation Medicine, Emory University, 1441 Clifton Rd NE, Atlanta, GA 30322, United States. nkutner@emory.edu
Telephone: +1-404-7125561 Fax: +1-404-7125895

Abstract

AIM: To assess the association of measured gait speed with hemodialysis (HD) patients' hospitalization, in conjunction with, and apart from, recent fall history.

METHODS: Gait speed was measured by a standard protocol and falls during the past 12 mo were ascertained for a prevalent multi-center HD cohort (*n* = 668) aged 20-92. Hospitalization during the past 12 mo was identified in the patient's clinic records, and the first hospitalization after gait speed assessment (or the competing event of death) was identified in the 2013 United States Renal Data System Standard Analysis Files.

RESULTS: Slow gait speed, defined as < 0.8 m/s, characterized 34.7% of the patients, and 27.1% had experienced a recent fall. Patients with slow gait speed but without a history of recent falls were 1.79 times more likely to have been hospitalized during the past 12 mo (OR = 1.79, 95%CI: 1.11-2.88, *P* = 0.02), and patients with slow gait speed and a history of recent falls were over two times more likely to have been hospitalized (OR = 2.10, 95%CI: 1.19-3.73, *P* = 0.01), compared with patients having faster gait speed and no recent fall history. Prospective examination of gait speed/fall history status in relation to first hospitalization (or death) incurred by the end of follow-up December 31, 2011 also showed that slow gait speed was associated with these events in conjunction with a history of falls (HR = 1.54, 95%CI: 1.04-2.30, *P* = 0.03).

CONCLUSION: The International Task Force on Nutrition and Aging reported that gait speed is a powerful predictor for older adults of adverse outcomes such as hospitalization. In our data, gait speed--apart from, as well as in conjunction with, recent fall history--was associated with HD patients' hospitalization for multiple causes. Gait speed may be a sensitive health indicator among HD patients across the age spectrum.

Key words: Falls; Gait speed; Hemodialysis; Hospitalization; Walking disability

Core tip: Walking places demands on the heart, lungs, circulatory, nervous, and musculoskeletal systems. Studies of older adults support the prognostic importance of slowed gait speed for the risk of poor health and function, including hospitalization. However, little is known about the association of gait speed with hemodialysis (HD) patient outcomes. The usual gait speed of 668 HD patients was measured in a United States Renal Data System special study. Slowed gait speed--apart from, as well as in conjunction with, recent fall history--was associated with HD patients' hospitalization for

multiple causes. Gait speed may be a useful monitoring tool in the HD clinical setting.

INTRODUCTION

The rate of hospital admissions among dialysis patients is high[1]. Hospitalization consumes a large portion of healthcare expenditures and is associated with risk for the patient. Identifying and understanding factors that may lead up to hospitalization is important for multiple quality improvement objectives[2].

In the geriatric population, a deficit in gait speed is recognized as a relatively easily measured and consistent prognostic indicator of patient outcomes, including hospitalization risk[3-5]. Studenski *et al*[5] have provided compelling evidence of the prognostic importance of slow gait speed for multiple health outcomes among older adults and have identified 0.8 m/s as a cutpoint below which gait speed connotes significantly increased likelihood of poor health and function and even mortality. End-stage renal disease (ESRD) patients appear to represent a model of early aging in many ways. While it is recognized that average gait speed is slower among ESRD patients compared with age-adjusted norms[6,7], the association of gait speed with ESRD patient outcomes has received limited attention.

A recent study by Beaubrun *et al*[8] of 52408 hemodialysis (HD) patients who were followed 2000-2009 reported that over one-fifth of patients who incurred a non-fracture-related hospitalization, and more than half of those who were hospitalized following a fracture, were characterized by "walking disability/history of falls". Medicare claims diagnoses of "difficulty walking" and "abnormal gait" define walking disability in administrative data[9]. Walking disability and falls are frequently associated[9]. At the same time, "walking disability" does not specify a quantitative measure of gait speed, and the potential association of walking disability with hospitalization apart from falls remains unknown when walking disability and history of falls are treated as one combined variable.

In this study of a large contemporary cohort of patients aged 20-92 undergoing maintenance HD therapy, we measured patients' gait speed and investigated its association with hospitalization in conjunction with, and apart from, patients' recent fall history.

MATERIALS AND METHODS

ACTIVE/ADIPOSE (A Cohort Study to Investigate the Value of Exercise in ESRD/Analyses Designed to Inves-

tigate the Paradox of Obesity and Survival in ESRD) is a multi-center study of prevalent patients on HD coordinated by the United States Renal Data System (USRDS). An overview of the study design and measures is available in the 2011 USRDS Annual Data Report[10]. Institutional review boards at Emory University and the University of California-San Francisco approved the study. A total of 668 study participants had gait speed and fall history information and are the focus of the analyses reported in this paper.

Usual gait speed was measured two times over a 15-feet walkway, and the average speed of the two trials was determined. Coordinators observed whether the participant used an assistive device for walking and whether an assistive device was used to perform the walk. For the analyses reported in this paper, slow gait speed was defined as < 0.8 m/s. Hospitalization during the past 12 mo was identified in the patient's clinic records, and the first hospitalization after gait speed assessment (or the competing event of death) was identified in the 2013 USRDS Standard Analysis Files.

Statistical analysis

Participants' sociodemographic and clinical characteristics were described by percentage or mean (SD) and compared using chi-square or t-test. A four-level variable was used to summarize participants' gait speed and fall history status, i.e. slow gait speed + no fall history; slow gait speed + fall history; faster gait speed + no fall history; faster gait speed + fall history. The association of this variable with hospitalization during the past 12 mo was examined in a multivariable logistic regression model, and time to first hospitalization (or death) through December 31, 2011 was examined in a multivariable Cox proportional hazards analysis using the USRDS 2013 Hospitalization Standard Analysis File; patients were censored at the end of follow-up. Statistical analyses were conducted using SAS 9.3 (SAS Institute, Cary, NC, United States).

RESULTS

Overall mean (SD) age of study participants was 57.1 (14.3); the median age was 57.5. The primary cause of ESRD was diabetes or hypertension in 72% of the cohort, similar to the total United States in-center HD population[1]. Forty-one percent were women, and median time since ESRD treatment start (ESRD vintage) was 3 years. Consistent with the study sites, African-American patients were more heavily represented than in the overall United States HD population, and the average age of study participants was correspondingly younger.

There were 103 patients who could not be included in the analysis due to lack of gait speed assessment or fall information. Compared with patients who had gait speed and fall information, patients missing this information were more likely to be women, older, and white; to have diabetes, congestive heart failure (CHF), coronary artery disease/myocardial infarction (CAD/MI), cerebrobascular accident/transient ischemic attack

Table 1 Characteristics of patients included (*n* = 668) and not included (*n* = 103) in the analysis			
	Measured walk and fall information (*n* = 668)	Missing measured walk or fall information (*n* = 103)[1]	*P* value
Male (%)	61.2	45.6	0.003
Age (yr), mean ± SD	56.3.(14.1)	62.2 (14.1)	< 0.001
Race (%)			< 0.001
White	22.2	31.1	
Black	63.6	45.6	
Native American	0.5	1	
Asian	10.9	12.6	
Other (Native Hawaiian, other Pacific Islander, other)	2.8	9.7	
ESRD vintage, yr, mean ± SD	5.0 (5.2)	4.4 (4.1)	0.24
Diabetes (%)	48.1	73.5	< 0.001
COPD (%)	7.5	11.8	0.14
Cancer (%)	7.7	9.8	0.46
CHF (%)	27.3	42.2	0.002
CAD/MI (%)	26	39.2	0.005
CVA/TIA (%)	9.3	15.7	0.047
PVD (%)	6.5	31.4	< 0.001
Other cardiac diseases (%)	23.9	43.1	< 0.001
KDQOL-CF score, mean ± SD	88.0 (16.3)	86.3 (18.2)	0.35
Hemoglobin, g/dL, mean ± SD	11.6 (1.3)	11.3 (1.3)	0.1
Assistive walking device (%)	19.5	91.7	< 0.001
History of recent fall(s) (%)	27.1	37.2	0.04

[1]One patient lacked fall history information only; no physical performance information was obtained for 19 patients; and study coordinators reported that 83 patients were not able to walk 15 feet to perform the walk test. CAD: Coronary artery disease; CHF: Congestive heart failure; COPD: Chronic obstructive pulmonary disease; CVA: Cerebrovascular accident; ESRD: End-stage renal disease; KDQOL-CF: Kidney Disease Quality of Life-Cognitive Function; MI: Myocardial infarction; m/s: Meters per second; Other cardiac disease: Cardiac dysrhythmia, atrial fibrillation, tachycardia, pericarditis, cardiac arrest; PVD: Peripheral vascular disease; TIA: Transient ischemic attack.

Table 2 Characteristics of patients with measured walk and fall information, by slow gait speed (< 0.8 m/s) and faster gait speed (≥ 0.8 m/s)			
	Gait speed < 0.8 m/s (*n* = 232)	Gait speed ≥ 0.8 m/s (*n* = 436)	*P* value
Male (%)	47	68.8	< 0.001
Age, yr, mean ± SD	62.1 (13.4)	53.2 (13.5)	< 0.001
Race (%)			< 0.001
White	13.8	26.6	
Black	75	57.6	
Native American	0.4	0.5	
Asian	8.2	12.4	
Other (Native Hawaiian, other Pacific Islander, other)	2.6	3	
ESRD vintage, yr, mean ± SD	4.5 (4.9)	5.2 (5.3)	0.1
Diabetes (%)	59.9	41.7	< 0.001
COPD (%)	12.1	5.1	0.001
Cancer (%)	8.2	7.4	0.71
CHF (%)	31.5	25.1	0.08
CAD/MI (%)	33.2	22.1	0.002
CVA/TIA (%)	12.5	7.6	0.04
PVD (%)	9.5	4.8	0.02
Other cardiac diseases (%)	29.3	21	0.02
KDQOL-CF score, mean ± SD	84.3 (18.0)	90.0 (14.9)	< 0.001
Hemoglobin, g/dL, mean ± SD	11.5 (1.3)	11.6 (1.3)	0.67
Assistive walking device (%)	45	6	< 0.001
Assistive walking device used when gait speed measured (%)	26.8	2.3	< 0.001
History of recent fall(s) (%)	36.2	22.3	< 0.001
Gait speed, m/s, mean ± SD	0.61 (0.15)	1.04 (0.18)	< 0.001

CAD: Coronary artery disease; CHF: Congestive heart failure; COPD: Chronic obstructive pulmonary disease; CVA: Cerebrovascular accident; ESRD: End-stage renal disease; KDQOL-CF: Kidney Disease Quality of Life-Cognitive Function; MI: Myocardial infarction; m/s: Meters per second; Other cardiac disease: Cardiac dysrhythmia, atrial fibrillation, tachycardia, pericarditis, cardiac arrest; PVD: Peripheral vascular disease; TIA: Transient ischemic attack.

(CVA/TIA), peripheral vascular disease (PVD) and other cardiac diseases; to use an assistive device for walking; and to report having fallen in the past 12 mo. Patients who lacked gait speed or fall information and could not be included in the analyses reported in this paper did not differ from the included patients with respect to ESRD vintage, chronic obstructive pulmonary disease (COPD), cancer, Kidney Disease Quality of Life-Cognitive Function (KDQOL-CF) score, or hemoglobin level (Table 1).

Characteristics of the 668 study participants who had gait speed measured are shown in Table 2. Corresponding mean (SD) gait speed values were 0.61 (0.15) m/s for those with slow gait speed *vs* 1.04 (0.18) m/s for those with faster gait speed; *P* < 0.001. Participants with slow gait speed were more likely to be women, older, and black. They were more likely to have diabetes, COPD, CAD/MI, CVA/TIA, PVD, and other cardiac diseases. Their average score on the KDQOL-CF scale was lower, they were more likely to use an assistive device for walking and to have used such a device to perform the walk

speed test, and they were more likely to report having fallen during the past 12 mo. Participants with slow gait speed and those with faster gait speed did not differ with respect to ESRD vintage, cancer, CHF, and average hemoglobin level.

Gait speed < 0.8 m/s characterized 34.7% of patients, and falling during the past 12 mo was reported by 27.1% of patients. Slow gait speed was more likely to characterize patients with a history of falls than patients without a history of falls (46% *vs* 30%, *P* < 0.001).

Almost half of the study cohort had been hospitalized in the past 12 mo, and 41% of those hospitalized had slow gait speed, compared with 29.3% of those who had not been hospitalized (*P* = 0.001). Patients with slow gait speed but no history of recent falls (*n* = 148) were 1.79 times more likely to have been hospitalized compared with patients with faster gait speed and no recent falls (*n* = 339) (OR = 1.79, 95%CI: 1.11, 2.88, *P* = 0.02). Patients with slow gait speed and a history of recent falls (*n* = 84) were over two times more likely to have been hospitalized compared with patients having faster gait speed and no recent fall history (OR = 2.10, 95%CI: 1.19, 3.73, *P* = 0.01). The risk of hospitalization among patients with faster gait speed and recent fall history (*n* =

Table 3 Characteristics associated with hospitalization in past 12 mo from multivariable logistic regression analysis

	[1]Adjusted odds ratios (95%CI) for Hospitalization	*P* value
Gait speed/fall history		
[2]Faster walk/no fall history (reference)	1	
[3]Slower walk/no fall history	1.79 (1.11, 2.88)	0.02
Slower walk/fall history	2.10 (1.19, 3.73)	0.01
Faster walk/fall history	1.46 (0.90, 2.39)	0.13
Female	0.55 (0.39, 0.78)	< 0.001
Age, yr	0.98 (0.97, 1.00)	0.01
ESRD vintage, yr	0.95 (0.92, 0.98)	0.003

[1]Adjusted also for race, diabetes, CHF, CAD, CVA, PVD, other cardiac diseases, COPD, cancer, hemoglobin level, KDQOL-CF score, assistive device use (variables not significantly associated in this logistic regression model with hospitalized/not hospitalized in past 12 mo); [2]Faster walk = gait speed $\geq$ 0.8 m/s; [3]Slower walk = gait speed < 0.8 m/s. ESRD: End-stage renal disease.

Table 4 Multivariable Cox proportional hazards model predicting index hospitalization/death[1] from baseline gait speed assessment through December, 2011

	[2]Adjusted hazard ratios (95%CI)	*P* value
Gait speed/fall history		
[3]Faster walk/no fall history (reference)	1	
[4]Slower walk/no fall history	1.11 (0.79, 1.56)	0.53
Slower walk/fall history	1.54 (1.04, 2.30)	0.03
Faster walk/fall history	1.47 (1.05, 2.05)	0.02
CAD	1.34 (1.01, 1.78)	0.04
Black race	2.09 (1.48, 2.94)	< 0.001
ESRD vintage, yr	1.02 (1.00, 1.04)	0.03

[1]Hospitalization events = 271; deaths = 17; [2]Adjusted also for age, diabetes, CHF, CVA, PVD, other cardiac diseases, COPD, cancer, hemoglobin level, KDQOL-CF score, assistive device use; [3]Faster walk = gait speed $\geq$ 0.8 m/s; [4]Slower walk = gait speed < 0.8 m/s. ESRD: End-stage renal disease.

97) was not significantly higher than the hospitalization risk among patients with faster walk and no recent fall history. Female sex, one-year increment in age, and one-year increment in ESRD vintage were associated with a lower risk for hospitalization (Table 3).

Patients with slower gait speed and a history of falls were more likely to incur subsequent hospitalization (or death) compared with the reference group of patients who had faster walk/no fall history (HR = 1.54, 95%CI: 1.04, 2.30, *P* = 0.03). In the Cox analysis, increased risk of these events was also evident for patients with faster walk and fall history, those with a history of CAD, and blacks, and a one-year increment in ESRD vintage was associated with increased likelihood of hospitalization/death (Table 4).

DISCUSSION

Slow gait speed, defined in this analysis as < 0.8 m/s, characterized one-third of the ambulatory HD patients whom we studied. Patients with gait speed < 0.8 m/s were more likely than those with gait speed $\geq$ 0.8 m/s to have been hospitalized during the past 12 mo, even in the absence of a history of recent falls. When we prospectively examined gait speed/fall history status in relation to first hospitalization (or death), patients with gait speed < 0.8 m/s and a history of falls were more likely to incur hospitalization/death than those with faster gait speed and no history of falls.

The causes of hospitalization among patients with slow gait speed varied widely, *e.g.*, cardiac issues, respiratory distress, mini-stroke, neuropathy, leg pain. Studenski *et al*[5] have emphasized that gait speed is a sensitive marker of health because it may reflect known and unrecognized disturbances in multiple organ systems. Walking places demands on the heart, lungs, circulatory, nervous, and musculoskeletal systems, and slowed gait may reflect damaged systems as well as a high-energy cost of

walking[5]. Mobility limitations can be early indicators of muscle weakness, pain or discomfort, and shortness of breath, as well as potential falls[7]. In addition, decreasing mobility may induce a cycle of reduced physical activity and deconditioning[5].

Slow gait speed may have contributed to "walking disability" in the Beaubrun *et al*[8] 2013 analysis of HD patients who were hospitalized following fracture. In their study, walking disability/history of falls characterized 55.6% of the study population[8]. The number of patients in our study cohort who were hospitalized following fracture was small (*n* = 24), but slow gait speed and fall history were prominent; 45.5% of patients hospitalized post-fracture had slow gait speed and 70.8% had recently fallen.

The International Task Force on Nutrition and Aging concluded that gait speed is strongly associated with adverse outcomes, including falls and hospitalization[11]. However, there has been little investigation of the association of gait speed with hospitalization hazard in the dialysis population. As we have noted, the recent study by Beaubrun *et al*[8] links walking disability/history of falls with hospitalization risk, but that study did not have information about gait speed.

The frailty index developed by Fried *et al*[12] includes slow walk as one component. Several studies of chronic kidney disease patients, both dialysis-dependent and non-dialysis-dependent, have measured gait speed and used the Fried index to classify patients as frail[13-18]. One of these studies investigated HD patients' hospitalization in association with frailty. McAdams-DeMarco *et al*[17], in a study of 146 HD patients in one dialysis center, found that 42.6% of frail participants, compared with 28.2% of nonfrail participants, had two or more hospitalizations in the year following study enrollment, and frailty was associated with 1.4 times (95%CI: 1.00-2.03, *P* = 0.049) more hospitalizations independent of age, sex, comorbidity, and disability[17]. The Fried index classi-

fies individuals as frail who have three or more of the five criteria that comprise the index (recent weight loss, reported exhaustion, weak grip strength, slow walk, and low physical activity)[12], which does not necessarily include having slow walk.

Our study has several strengths. Data were supplied by a large multi-center study cohort. Performance-based gait speed was carefully assessed, along with a large number of patient characteristics and treatment-related factors. The fall prevalence that we observed was very similar to 12-mo fall prevalence estimates from other studies[19]. We acknowledge, however, that although the ACTIVE-ADIPOSE cohort shares many similarities with the general ESRD population, the rate of fracture-related hospitalization would be expected to be higher in a cohort with higher representation of whites and older patients[8]. In addition, having been hospitalized over the past 12 mo could have influenced participants' gait speed, and prospective examination of hospitalization events was truncated for study participants whose baseline gait speed assessments were obtained near the end of the study enrollment period in 2011. These also represent potential study limitations.

We used the cutoff of < 0.8 m/s to define slow gait speed, the cutoff that has been most often observed to predict adverse health outcomes among older adults[11]. However, 0.6 m/s and 1.0 m/s have been used as cut-offs in other studies[5,7]. Most of the existing evidence about gait speed and outcomes is derived from studies of older, community-dwelling populations. Investigation of other gait speed cut points may be useful in dialysis cohorts that have a different sociodemographic and/or clinical profile compared with the cohort we studied. Studenski *et al*[5] noted that further work is needed to examine associations of gait speed with outcomes such as disability and health care use, especially in populations based in clinical practice.

Gait speed provides a straightforward and informative indicator of health status. It may offer the clinician a tool for assessing expected outcomes and tailoring goals of care[5]. Compared with patient-reported mobility difficulty, a gait speed test provides a quantitative marker that facilitates tracking mobility changes[7]. Referral to a specialist (physical therapist, clinical exercise specialist, cardiac rehabilitation) for further evaluation and intervention may be indicated. Gait speed performance can be assessed relatively easily and quickly (less than two minutes) in the clinical setting, and poor performance may indicate that there are underlying health problems placing the patient at increased risk for hospitalization, as well as for other potential adverse outcomes.

ACKNOWLEDGMENTS

COMMENTS

Background
Usual gait speed has been shown to be a powerful predictor of outcomes, including hospitalization, among older persons, and hemodialysis (HD) patients represent a model of early aging. Frailty, which may include slow gait speed, has been shown to be associated with HD patients' hospitalization risk, as has the syndrome of "walking disability/history of falls," but the utility of gait speed alone as a predictor of HD patients' hospitalization has not been studied.

Research frontiers
There is growing recognition of the significance of physical performance deficits among chronic kidney disease (CKD) patients, including increased mortality risk. Measures of lower extremity function may capture a complex set of skeletal muscle and neurologic impairments that develop in individuals with CKD and may substantially affect their survival as well as their independent physical functioning. Research frontiers include identifying mechanisms that underlie decreased physical performance and evaluating whether interventions that improve physical performance may also positively influence comorbidity and clinical outcomes in CKD.

Applications
Gait speed can be considered a vital sign, and measuring gait speed is simple, quick, reproducible, inexpensive, and feasible in clinical settings.

Terminology
Gait speed is typically measured as the time it takes an individual to walk at a usual pace over a measured distance (usually 4 to 6 meters). The time for that distance is then converted into a speed in m/s.

Peer review
Clearly stated study indicating that slow measured walking speed in dialysis patients can be used as a predictor of subsequent fracture and hospitalization for all causes.

REFERENCES

1   **US Renal Data System**. USRDS 2013 Annual Data Report: Atlas of Chronic Kidney Disease and End-Stage Renal Disease in the US. Bethesda, MD: National Institutes of Health, National Institute of Diabetes and Digestive and Kidney Diseases, 2013: 237-248

2   **Fotheringham J**, Caskey F. Predicting hospital admissions by looking backwards: an alternative perspective. *Nephrol Dial Transplant* 2014; **29**: 225-227 [PMID: 24186899 DOI: 10.1093/ndt/gft440]

3   **Montero-Odasso M**, Schapira M, Soriano ER, Varela M, Kaplan R, Camera LA, Mayorga LM. Gait velocity as a single predictor of adverse events in healthy seniors aged 75 years and older. *J Gerontol A Biol Sci Med Sci* 2005; **60**: 1304-1309 [PMID: 16282564 DOI: 10.1093/gerona/60.10.1304]

4   **Viccaro LJ**, Perera S, Studenski SA. Is timed up and go better than gait speed in predicting health, function, and falls in older adults? *J Am Geriatr Soc* 2011; **59**: 887-892 [PMID: 21410448 DOI: 10.1111/j.1532-5415.2011.03336.x]

5   **Studenski S**, Perera S, Patel K, Rosano C, Faulkner K, Inzitari M, Brach J, Chandler J, Cawthon P, Connor EB, Nevitt M, Visser M, Kritchevsky S, Badinelli S, Harris T, Newman AB, Cauley J, Ferrucci L, Guralnik J. Gait speed and survival in older adults. *JAMA* 2011; **305**: 50-58 [PMID: 21205966 DOI: 10.1001/jama.2010.1923]

6   **Johansen KL**, Chertow GM, da Silva M, Carey S, Painter P. Determinants of physical performance in ambulatory patients on hemodialysis. *Kidney Int* 2001; **60**: 1586-1591 [PMID: 11576377 DOI: 10.1046/j.1523-1755.2001.00972.x]

7   **Painter P**, Marcus R. Physical function and gait speed in patients with chronic kidney disease. *Nephrol Nurs J* 2013; **40**: 529-538; quiz 539 [PMID: 24579399]

8   **Beaubrun AC**, Kilpatrick RD, Freburger JK, Bradbury BD, Wang L, Brookhart MA. Temporal trends in fracture rates

and postdischarge outcomes among hemodialysis patients. *J Am Soc Nephrol* 2013; **24**: 1461-1469 [PMID: 23744885 DOI: 10.1681/ASN2012090916]

9   **US Renal Data System**. USRDS 2008 Annual Data Report: Atlas of Chronic Kidney Disease and End-Stage Renal Disease in the US. Bethesda, MD: National Institutes of Health, National Institute of Diabetes and Digestive and Kidney Diseases, 2008: 112-115

10 **US Renal Data System**. USRDS 2011 Annual Data Report: Atlas of Chronic Kidney Disease and End-Stage Renal Disease in the US. Bethesda, MD: National Institutes of Health, National Institute of Diabetes and Digestive and Kidney Diseases, 2011: Chapter 9

11 **Abellan van Kan G**, Rolland Y, Andrieu S, Bauer J, Beauchet O, Bonnefoy M, Cesari M, Donini LM, Gillette Guyonnet S, Inzitari M, Nourhashemi F, Onder G, Ritz P, Salva A, Visser M, Vellas B. Gait speed at usual pace as a predictor of adverse outcomes in community-dwelling older people an International Academy on Nutrition and Aging (IANA) Task Force. *J Nutr Health Aging* 2009; **13**: 881-889 [PMID: 19924348 DOI: 10.1007/s12603-009-0246-z]

12 **Fried LP**, Tangen CM, Walston J, Newman AB, Hirsch C, Gottdiener J, Seeman T, Tracy R, Kop WJ, Burke G, McBurnie MA. Frailty in older adults: evidence for a phenotype. *J Gerontol A Biol Sci Med Sci* 2001; **56**: M146-M156 [PMID: 11253156 DOI: 10.1093/gerona/56.3.M146]

13 **Shlipak MG**, Stehman-Breen C, Fried LF, Song X, Siscovick D, Fried LP, Psaty BM, Newman AB. The presence of frailty in elderly persons with chronic renal insufficiency. *Am J Kidney Dis* 2004; **43**: 861-867 [PMID: 15112177 DOI: 10.1053/j.ajkd.2003.12.049]

14 **Wilhelm-Leen ER**, Hall YN, K Tamura M, Chertow GM. Frailty and chronic kidney disease: the Third National Health and Nutrition Evaluation Survey. *Am J Med* 2009; **122**: 664-671. e2 [PMID: 19559169 DOI: 10.1016/amjmed.2009.01.026]

15 **Roshanravan B**, Khatri M, Robinson-Cohen C, Levin G, Patel KV, de Boer IH, Seliger S, Ruzinski J, Himmelfarb J, Kestenbaum B. A prospective study of frailty in nephrology-referred patients with CKD. *Am J Kidney Dis* 2012; **60**: 912-921 [PMID: 22770927 DOI: 10.1053/j.ajkd.2012.05.017]

16 **Painter P**, Kuskowski M. A closer look at frailty in ESRD: getting the measure right. *Hemodial Int* 2013; **17**: 41-49 [PMID: 22716227 DOI: 10.1111/j.1542-4758.2012.00719.x]

17 **McAdams-DeMarco MA**, Law A, Salter ML, Boyarsky B, Gimenez L, Jaar BG, Walston JD, Segev DL. Frailty as a novel predictor of mortality and hospitalization in individuals of all ages undergoing hemodialysis. *J Am Geriatr Soc* 2013; **61**: 896-901 [PMID: 23711111 DOI: 10.1111/jgs.12266]

18 **Reese PP**, Cappola AR, Shults J, Townsend RR, Gadegbeku CA, Anderson C, Baker JF, Carlow D, Sulik MJ, Lo JC, Go AS, Ky B, Mariani L, Feldman HI, Leonard MB. Physical performance and frailty in chronic kidney disease. *Am J Nephrol* 2013; **38**: 307-315 [PMID: 24107579 DOI: 10.1159/000355568]

19 **Kutner NG**, Zhang R, Huang Y, Wasse H. Falls among hemodialysis patients: potential opportunities for prevention? *Clin Kidney J* 2014; **7**: 257-263 [DOI: 10.1093/ckj/sfu034]