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Assessment of physical functioning in the clinical care of the patient with advanced kidney disease

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Abstract

Maintenance of independent living is the top health priority among patients with advanced chronic kidney disease (CKD). Mobility limitation is often the first sign of functional limitation leading to loss of independence. Regular assessments of physical capacity can help provide kidney health providers identify patients at risk of frailty and other adverse health related outcomes that contribute to the loss of functional independence. These physical capacities can be measured with commonly used self-reported measures of physical function or by objective physical performance testing. The current review describes commonly used assessments of self-reported physical function and physical performance. First, we describe the disablement process and how these assessments can be performed with commonly used quality of life instruments measuring self-reported physical function or objective physical performance tests. Second, we identify the determinants and correlates of self-reported physical function and physical performance and their contribution to the frailty phenotype. Third we describe the association of physical capacities with clinical outcomes. We conclude with on possible approach to identifying and intervening on persons with CKD at high risk of functional decline.

Introduction

Persons with advanced chronic kidney disease (CKD) suffer a substantially reduced quality of life as reflected in the high prevalence of poor physical function across the spectrum of kidney disease. Reduction in kidney function is associated with pathophysiologic processes that increase vulnerability to physiologic stressors and contribute to the loss of functional independence. Maintenance of independent living is the top health priority among patients with advanced CKD,[1] requiring the physical capacity to complete daily activities. Regular assessments of physical capacity can help provide kidney health providers identify patients at risk of frailty and other adverse health related outcomes that contribute to the loss of functional independence. These physical capacities can be measured with commonly used self-reported measures of physical function or by objective physical performance testing.

Persons living with advanced CKD, treated with or without renal replacement therapy, suffer from lower self-reported physical function[2–4] and impaired physical performance[5,6]

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contributing to the high prevalence of frailty[7,8], mobility disability[6,9,10] and increased risk of mortality[11–13]. The gerontological model of the disablement process helps conceptualize and operationalize the pathology of reduced kidney function leading to disability identifying the role of different types of assessments for different stages of disablement. Figure 1 illustrates the disablement process and how these assessments can be performed with commonly used quality of life instruments measuring self-reported physical function or objective physical performance tests.

In the context of the disablement framework, reduced kidney function and CKD leads to the retention of uremic solutes inciting pathophysiologic processes contributing to organ impairment (e.g. skeletal muscle dysfunction or sarcopenia), initially manifesting as weakness or fatigue and culminating in functional limitations and ultimately disability. Fatigue and strength can be assessed through self-reported items of physical function encompassing mobility or objective measures of muscle fatigue and strength (e.g. distance walked during 6 minutes or repeated sit to stand testing). Functional limitations are measured by basic physical performance tests (e.g. gait speed, timed up and go (TUG)) or as self-reported mobility limitation (i.e. difficulty walking ¼ mile or climbing 10 steps). Frailty is a related phenotype defined as a clinical syndrome of vulnerability traditionally characterized by possessing at least three of the following five features: weak grip strength (muscle impairment), slow gait speed (physical performance), low physical activity, low energy, and weight loss[14] (Figure 1).

In the United States, under the current conditions of coverage by Centers for Medicare & Medicaid Services (CMS), dialysis facilities are required to assess self-reported health related quality of life annually. Unfortunately, CMS does not provide actionable guidance for patients who score poorly on these instruments. This review will focus on the describing commonly used and well-validated tools available to help kidney health providers assess physical capacities. We will also discuss the determinants of physical function assessed by these tools, and clinical relevance of self-reported physical function and physical performance in the kidney disease population. Finally, we provide one possible approach to identifying and intervening on patients at high risk of functional decline.

Assessment of physical function by self-report

The Short Form 36 Health Survey (SF-36) is one of the most widely used self-report generic 36-item HRQOL measures applied across multiple populations[15]. The SF-36 includes 36 items evaluating functional status, and perceptions of health status in 8 scales scored from 0 to 100 with higher scores associated with greater perceived HRQOL. These scales include physical functioning, role physical (limitations of work accomplishments), bodily pain (pain interfering with work), general health perception (rating of health relative to others), vitality (energy and tiredness), social functioning (limitations to time and type of social activities), role emotional (reduced work time, accomplishment and quality), and mental health (anxiety/serenity, depressed mood/happiness). The physical component score (PCS) of the SF-36 is a summary of the physical functioning, role physical, bodily pain, and general health scores. The physical function subscale (PF-10) is comprised of 10 items, several of which measure mobility function (Table 1). Respondents are requested to indicate if they are limited a lot, a little, or not at all in their ability to perform each activity or task.

The Kidney Disease Quality of Life (KDQOL-36-SF and KDQOL-36) includes a generic core SF-36 measure of physical functioning and is supplemented with multi-item scales intended to capture the unique burden of uremia and its treatment by hemodialysis as reported by patients[16,17]. A recent comprehensive systematic review demonstrated that among advanced kidney disease population treated with dialysis, the KDQOL-SF demonstrated the most robust psychometric properties compared with other instruments assessing HRQOL in this population[18]. There was strong evidence supporting internal consistency and structural validity and moderate evidence for test-retest reliability and construct validity. The authors concluded that the available evidence supported the use of the KDQOL-36 for pre-dialysis CKD patients and the KDQOL-SF or KDQOL-36 for dialysis patients. This recommendation has been bolstered by support from the ERA-EDTA expert panel encouraging the widespread use of the KDQOL-36 or the SF-12, a 12-item version of the SF-36[19].

Comparison of the Physical versus Mental Component Scores.—The generic core SF-36 and the abbreviated form SF-12 encompassed in the KDQOL have been widely investigated in advanced kidney disease and have demonstrated high correlation and agreement. In particular there is high correlation (r>0.9) and agreement between respective summary scores (PCS-36/PCS-12 and MCS-36/MCS-12) among end-stage kidney disease (ESKD) patients treated with in-center hemodialysis, home hemodialysis and peritoneal dialysis[20]. The initial description of the KDQOL instrument compared the SF-36 measures among patients treated with dialysis to the general population[16]. Kidney disease patients had substantially worse scores compared to the general population on the PCS subscale scores (1 full standard deviation lower on physical function, role limitations due to physical health and general health) and to a lesser degree on measures of the Mental Component Score (MCS).

Later reports confirmed that when compared to the US general population, patients living with CKD treated with or without dialysis had substantially worse PCS scores with relatively minor to no meaningful reductions in MCS scores[20–23]. One investigation demonstrated patients with CKD stages 3–5 not treated with dialysis had similar PCS scores compared with CKD patients treated with dialysis, underscoring that pathophysiologic processes of reduced kidney function contribute to poor physical functioning before the initiation of renal replacement therapy[23].

Correlates and determinants of the PCS.—The initial description of the KDQOL instrument detailed the connection between the physical health and mental health dimensions of the SF-36 and their ability to capture kidney disease specific health burden. Physical health and mental health dimensions of the SF-36 were moderately correlated to each other (r=0.55) and equally correlated (r=0.59 and r=0.60 respectively) to kidney disease specific burden (cognitive function, absence of symptoms, effects of kidney disease on daily life, sexual function, and sleep)[16]. On the other hand, neither dimension correlate with biochemical markers in patients with CKD treated with dialysis such as Kt/V, serum albumin, hemoglobin, calcium or phosphorus[24].

More recent studies suggest that demographics, physical performance, and physical activity are significant determinants of the PCS. Among patients living with CKD enrolled in the Chronic Renal Insufficiency Cohort (CRIC), the PCS was shown to be associated with age, gender, race, education, smoking status, and comorbidity. In particular lower PCS score (based on the SF-12) were observed in participants who were older (65 and older versus <65 years), female, black or Hispanic race, had lower income, had lower education, increased comorbidities, greater BMI, had albuminuria, and lower estimated glomerular filtration rate (eGFR)[22]. Factors associated with increased odds of low baseline PCS score, defined as >1standard deviation below the cohort mean, included female gender, low education, current or past smoking, diabetes, history of myocardial infarction, peripheral vascular disease, congestive heart failure, BMI≥30, and lower eGFR[22].

One small study of patients with kidney disease treated with maintenance hemodialysis indicated significant associations of the PCS (from the SF-36) with physical activity and physical performance. Greater PCS scores positively correlated with self-reported physical activity by Human Activity Profile (HAP) (r=0.46, P<0.01) and digital actigraphy (r=0.29, P<0.05)[25]. Furthermore, the PCS was also modestly correlated with physical performance. The PCS correlated more strongly with sit-to-stand test performance (r=0.41, P<0.05) compared to the 6-minute walk test (r=0.26, P<0.01). A notable finding in this study was the vitality (energy/fatigue) subscale was similarly correlated with self-reported physical activity by HAP and physical performance as the PCS score. Further studies in larger populations of patients with CKD are necessary to confirm that self-reported measures of physical function and vitality capture objectively measured physical performance since they provide complementary assessment of physical capacity and are strongly associated with mortality and hospitalization.

Intervention studies testing dialysis dose, frequency, and time on dialysis have demonstrated beneficial effects on the PCS. Results from the HEMO study, a randomized clinical trial examining the effects of hemodialysis dose and hemodialyzer flux on outcomes, suggested that over a 3-year follow-up high dose hemodialysis (eKt/V 1.45 vs 1.04) was associated with less bodily pain (4.49 points, p<0.001) and higher PCS (1.23 point, P=0.007) compared to lower dose dialysis, but no difference was observed between high and low flux dialyzers.

The frequent hemodialysis network (FHN) randomized controlled trial demonstrated that increased frequency hemodialysis (6 times weekly) significantly improved PCS (3.4 versus 0.4 points, P=0.009) but not physical performance by Short Physical Performance Battery (SPPB) (P=0.45) compared with conventional thrice weekly hemodialysis[26,27]. Consistent with results of the FHN trial, the ACTIVE dialysis randomized trial demonstrated that extended weekly (≥24hours) was associated with improved PCS (2.68 points, P=0.02) but no difference in MCS (p=0.27) compared with standard hemodialysis (12–15 hours). In comparison to increased time and frequency of hemodialysis, there is no evidence to support hemodiafiltration over high-flux hemodialysis[28].

Consequences of poor Physical Component Scores.—Observational studies have demonstrated a strong, consistent relationship between PCS with hospitalization and mortality in patients with CKD[20,22,29,30]. Among 44,395 patients with CKD treated with long-term hemodialysis at Fresenius Medical Care, North America facilities, each 1-point increment in baseline PCS-36 and PCS-12 has been associated with 2.4% lower risk of death and 0.4% lower risk of first hospitalization after adjustment for demographics, diabetes, hemoglobin, albumin, biochemical markers, as well as dialysis duration and standard Kt/V ($P<0.0001$ for both)[20]. The risk of hospitalization in this study was noted to increase with PCS-12/36 scores below 44.

Results from the Dialysis Outcomes and Practice Patterns study (DOPPS) demonstrated that PCS was mores strongly associated with risk of hospitalization and mortality than MCS[20]. Furthermore, a decline in PCS over time increased risk of mortality with each 5-point decrease in PCS associated with a 9% increase in mortality[31] underscoring that both low PCS and decline in PCS are important considerations in risk stratification of CKD patients treated with dialysis.

Despite evidence demonstrating the strong association of PCS scores with mortality and hospitalization, there is a lack of understanding of how baseline PCS scores among those who are free of mobility or activities of daily living (ADL) disability is associated with important functional endpoints such as falls or decline in mobility, central to functional independence. Interestingly, bodily pain and poor vitality, both components of the PCS, have also been associated with increased risk of death and hospitalization in patients treated with hemodialysis[30,32].

Among patients with CKD not treated with dialysis enrolled in the Chronic Renal Insufficiency Cohort (CRIC), only low PCS scores have been associated with increased rates of progression of CKD, cardiovascular events and death[22]. In particular, after adjustment for confounders, only low PCS defined as a score >1 SD below the mean for the cohort (PCS score <29.8) was associated with both higher risk of CV events and death. In comparison low MCS was associated with higher risk of death but not incident CV disease. Results from CRIC further indicate that associations between PCS and outcomes parallel those of the effects of kidney disease (the degree to which kidney disease interferes with a patient's life) and outcomes. This important observation confirms that PCS captures the effects of kidney disease and may be important in identifying high-risk frail patients at risk of mortality.

Physical function subscale 10 (PF-10) of the PCS as a component of frailty— Frailty is defined as a clinical syndrome of vulnerability traditionally characterized by weak grip strength (muscle impairment), slow gait speed (physical performance), low physical activity, low energy, and weight loss[14]. The presence of 3 or more of these characteristics is requisite for frailty. The frailty phenotype is strongly associated with disability, hospitalization and mortality across multiple populations[8,33–36]. The frailty syndrome has been operationalized in several different ways in the kidney disease population and all are strongly associated with mortality[37–39]. Among older adults and patients with CKD, lower kidney function is associated with greater risk of frailty[7,40]. Importantly, frailty among patients with CKD has been associated with increased risk of death or dialysis initiation[7].

Recently Johansen et al defined a phenotype of frailty based entirely on self-report substituting the self-reported physical function using the PF-10 of the SF-36 for objectively measured gait speed and grip strength and the vitality scale of the SF-36 for exhaustion in 762 patients treated with chronic hemodialysis enrolled in the ACTIVE/ADIPOSE study[38]. A PF-10 score <75 defined both weak grip strength and slow walking speed. A vitality scale score of <55 defined exhaustion. The cut-point of a PF-10 score<75 for poor physical function was first identified in the Women's Health Initiative and further informed by findings in the Dialysis Morbidity and Mortality Wave 2 study demonstrating that a PF-10<75 was independently associated with a 2-fold increase in risk of death and 1.4-fold increase risk of hospitalization or death[13]. When compared with the gold standard performance-based definition of frailty, the self-report definition had 85% sensitivity and 63% specificity with a positive predictive value of 52% and negative predictive value of 90%. The self-report definition of frailty missed 15% of frail patients by the performance-based definition.

Both the self-report and performance-based definitions of frailty were strongly associated with mortality after adjustment. Notably, those who were frail by only the self-reported criteria and not by the performance based-criteria were not at increased risk. This discrepancy may be explained by the misclassification of 25% of those who reported low functioning by PF-10 scores without observable evidence of poor physical performance.

Despite these limitations, the ease and feasibility of defining frailty from the routinely administered KDQOL and its excellent negative predictive value argue for its use as a potential screening tool for frailty. Confirmation of frailty however, would still require confirmatory physical performance testing of strength and mobility limitation.

Assessment of mobility limitation by self-report and physical performance testing in patients with CKD

Difficulty with mobility function is often the first manifestation of functional limitation and increased vulnerability to functional decline. Mobility limitations can be assessed by self-report or objectively by physical performance testing, providing complementary insight into disease burden on functioning[41]. Questions probing self-reported modifications in performing mobility tasks are particularly helpful complements to physical performance testing in screening preclinical mobility disability (PCMD) and functional limitations. PCMDs are defined as limitations that only exist in challenging environments and increase risk for mobility disability[42,43].

Assessment of PCMD is particularly important in patients with CKD given the particularly high risk of decline in mobility[10,44,45]. Several screening questions have been proposed to assess PCMD derived from questions included in the PF-10 such as difficulty climbing 10 stairs or walking 0.25 mile (or several blocks). Follow-up questions assessing self-reported modifications in performing these mobility tasks may help unveil increased vulnerability to PCMD and functional limitations.

To date, there has been no universally accepted cut-off score for the PF-10 in CKD. Some studies in CKD patients treated with dialysis have suggested a PF-10 score <75 as defining poor physical function based on findings from the large Women's Health Initiative[13,38,46] and others demonstrate significant increase in mortality risk with <50[47]. Given that a positive screen based on a PF-10 of <75 may misclassify 25%[38] of patients, it is important to confirm mobility limitation with physical performance testing.

Objective physical performance tests such as gait speed, timed up and go, and 6-minute walk distance are strongly associated with mobility disability and death across multiple populations (Table 2). The objective nature of physical performance assessment addresses some of the limitations of self-reported measures of physical function such as patient accommodation and inter-individual differences in living environment (i.e. presence or absence of stairs or walk-in shower in the living environment) that may influence responses. Across the spectrum of CKD, worse physical performance is strongly associated with early initiation of dialysis or mortality[6,7,11,45]. The most frequently studied physical performance measure in CKD is gait speed, a key measure of mobility, and critical component of the frailty phenotype.

Patients with ESKD treated with chronic dialysis are more likely to develop mobility limitation defined by slow gait speed compared with other frailty components, contributing to increased risk for disability and mortality[45]. Slow gait speed among dialysis patients is associated with increased risk of mortality, and 1-year odds of hospitalization or ADL disability[6]. Among CKD patients treated with dialysis, gait speed is associated with mortality in a continuous fashion whereas thresholds of <1m/s have been associated with increased 1-year odds of new hospitalization and <0.8m/s with 1-year odds of ADL difficulty. Furthermore, development of slow gait speed during follow-up was strongly associated with increased risk of mortality independent of the development of other frailty components even after adjusting for demographics, BMI, comorbidity, and albumin levels[45]. The high likelihood of developing mobility limitation and the subsequent risk of death among patients treated with dialysis underscores the need for early mobilization of rehabilitation or physical therapy services in this vulnerable patient population.

The 6-minute walk distance (6MWD) is a measure of submaximal physical performance strongly associated with mortality in CKD. This test measures the maximal distance covered during 6 minutes. Persons with CKD on average demonstrate 30–40% lower performance on the 6MWD than predicted for age and gender[11]. The 6MWD may also capture the impact of kidney disease on skeletal muscle wasting and important target of uremia and final common pathway for processes leading to functional decline[48]. Indeed, thigh muscle size determined from magnetic resonance imaging (MRI) is an important determinant of not only self-reported PCS from the SF-12, but also performance on the 6MWD among patients with ESKD treated with chronic dialysis[49].

Among patients with CKD, the 6MWD out-performed grip strength in predicting 3-year mortality. In fact any physical performance test assessing mobility such as usual gait speed or 6MWD outperformed any single biomarker of kidney disease including eGFR, serum bicarbonate, hemoglobin, or inflammatory markers in predicting 3 year mortality[11]. Walking less than 350 meters on the 6MWD was associated with an 82% greater risk of mortality compared to 350 meters or greater[11]. Among patients with ESKD treated with dialysis, every 20 meters greater performance on the 6MWD is associated with a 11% reduction in risk of mortality[50].

Adding to the clinical relevance of the 6MWD is the observation that structured physical activity interventions improve 6MWD[51] underscoring its usefulness in tracking therapeutic response to lifestyle interventions in persons living with CKD. The feasibility of applying this test in clinical practice however is limited by the amount of free space necessary to adequately perform the test and the training necessary to ensure a standardized testing approach to avoid interrater variability in assessment.

Exercise interventions to improve physical function.

The most modifiable component of the frailty phenotype in patients with kidney disease is physical inactivity[7]. Interventions that increase physical activity may act as a model for preventing or mitigating frailty,[52] while decline in physical activity predict, early on, the development of the rest of the frailty phenotype by leading to the loss of physical function[53].

Several recent extensive reviews and meta-analyses have demonstrated benefits of short-term, supervised exercise training on fitness (VO_{2peak}), sarcopenia (leg muscle mass, quadriceps cross-sectional area and strength), physical performance, self-reported physical function, and quality of life (QOL) among participants with advanced CKD, including dialysis dependent populations[48,54–56]. Benefits were observed regardless of the type of exercise.

The EXerCise Introduction to Enhance performance in dialysis patient trial (EXCITE) is the largest exercise study demonstrating the effectiveness of a 6-month personalized, home-based walking exercise program to improve walking capacity and muscle strength compared to “usual care”[51]. This multicenter randomized, controlled trial in the dialysis population excluded those with limited mobility or high degree of fitness (6-minute walk distance >550meters), exertional angina, or stage 4 NYHA heart failure. Dialysis staff trained by a rehabilitation team supervised participants in a personalized home-based exercise program. Exercise training involved gradual increased intensity of walking cadence using a low-cost metronome. Baseline recommendations for walking cadence (speed or steps/min), partition of work and resting time, and number of repetitions were determined by performance on the 6-minute walk test.

During the 6 months of training 31% of participants withdrew from the exercise group compared with 15% from the control. In addition, 47% of those who completed the study were designated as having low adherence to the protocol (<60% of sessions completed). Hospitalization was only reduced among those in the exercise group that had completed the trial compared to controls that completed the trial, but not in the intent-to-treat analysis. Among those who completed the trial, there were meaningful and significant improvements in muscle strength and endurance compared to the control group. Furthermore, there was a dose dependent effect with greater adherence associated with greater improvement in physical performance measures.

Several reviews are available to help guide kidney health providers on counseling patients to improve physical activity and engage in exercise[48,57,58].

Conclusion

Maintenance of functional independence is a top priority among patients with advanced kidney disease. Assessment of physical capacities and identification of functional limitations is essential to those patients with kidney disease at high risk of frailty, hospitalization, and mortality. Mobility limitation is often the first sign of functional limitation and can be assessed by self-report from routinely administered KDQOL questionnaires in dialysis centers required as part of the CMS conditions of coverage and by objective physical performance. Poor physical functioning characterized by a KDQOL-36 physical functioning subscale score (PF-10)<75 is associated with increased risk of hospitalization or death in CKD patients treated with dialysis and serves as a readily available screen for patients at risk of mobility impairment. Usual gait speed assessment is an appropriate confirmatory test to identify high risk patients who may benefit from further review of medical history and early mobilization of rehabilitation services. The concluding figure (figure 2) provides one suggested algorithm to screen and identify patients with advanced kidney disease at high risk of functional decline.

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Practical Tips for Nephrologists

- Physical function assessed by the physical component score (PCS) of the KDQOL or physical performance tests (usual gait speed) are useful measures of physical capacities identifying those persons at risk for functional decline.
- Asking patients about increasing difficulty or new inability to walk or climb stairs is a simple way to screen for risk of functional decline, confirmed using the PF-10 questionnaires or usual gait speed assessment.
- Regular assessment of mobility limitation by kidney health providers annually or after each hospitalization is critical to identify those at risk of frailty and adverse health-related outcomes.

Box 2.

Areas for Future Research

- Investigation of the association of physical capacities with risk of mobility decline to identify specific cut-points for persons with CKD and end stage kidney disease (ESKD).
- Investigation of the association of body pain and fatigue with mobility decline

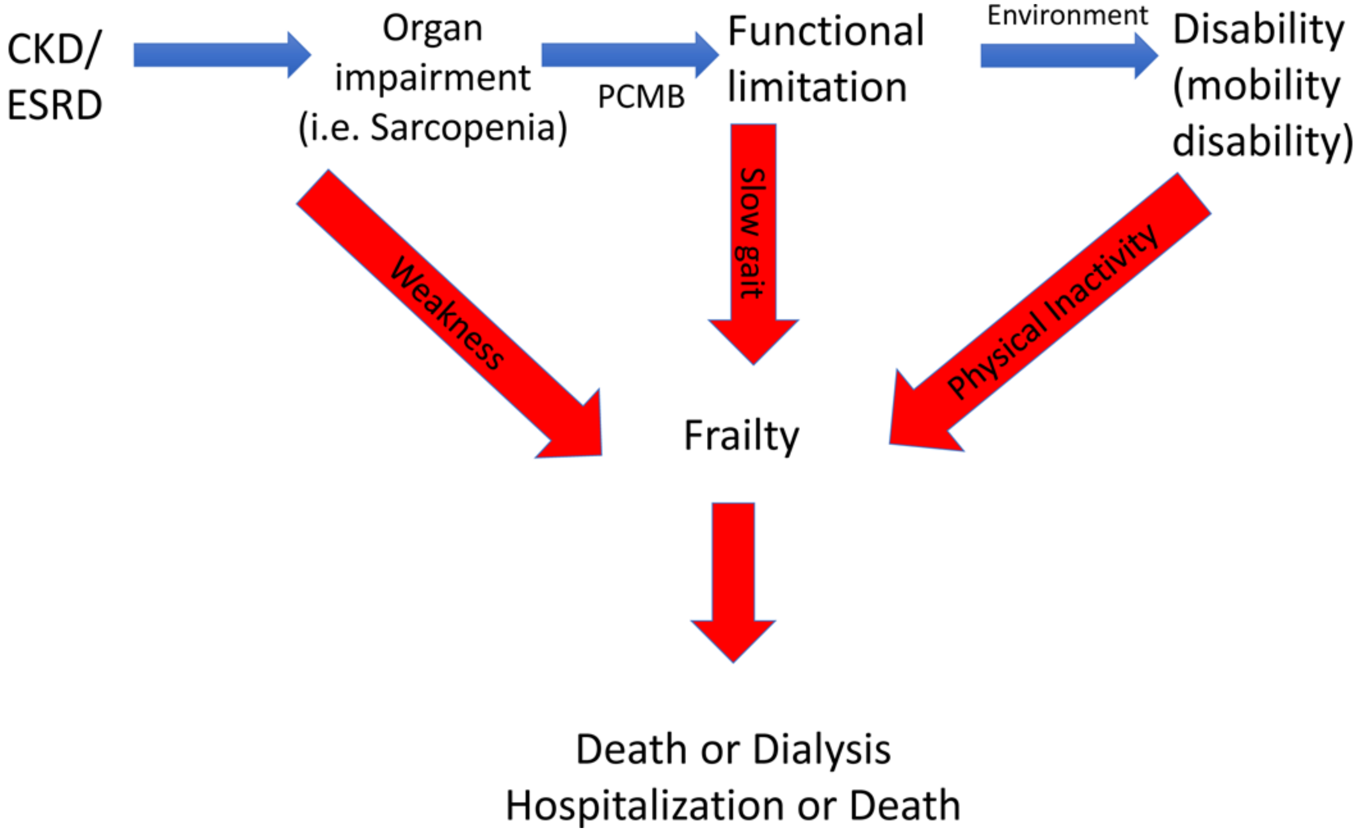

Figure 1.

CKD contributes to muscle impairment promoting functional decline, mobility disability, and frailty. This figure represents CKD in the context of the Nagi disablement model. Abbreviations: PCMD – preclinical mobility disability.

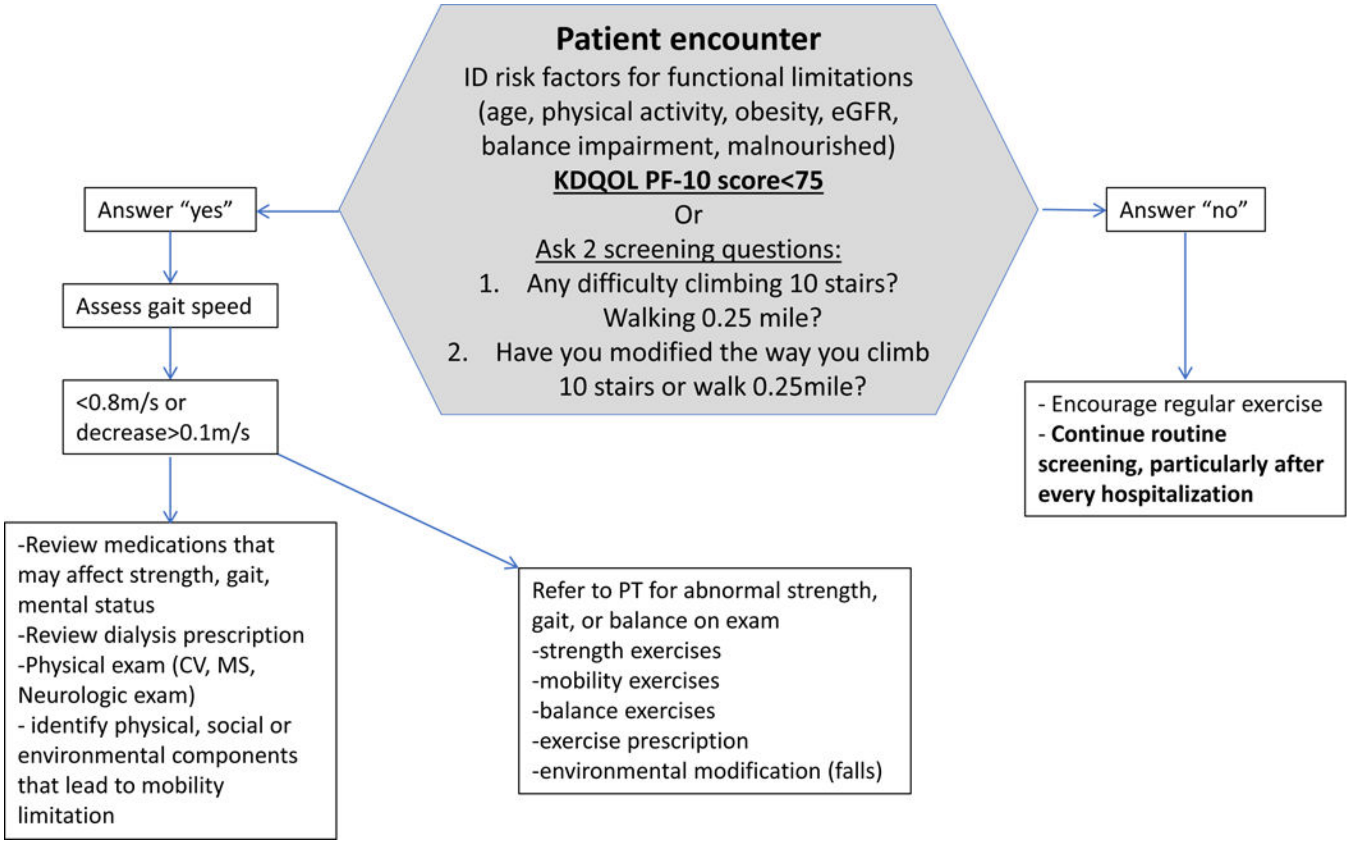

Figure 2.

Algorithm for two-step screening of functional limitations among high-risk patients with CKD and early referral for rehabilitative therapies prior to initiation of exercise. Abbreviations: CV- cardiovascular, MS – musculoskeletal, Neuro – neurologic, PT – physical therapy.

Table 1.

Components of the SF-36 organized by domains with indication of embedded SF-12 questions and PF-10.

SF-36 Questions	Domains	PCS	PF-10	MCS	SF-12
Health now versus 1 year ago	NA				
Limitations in vigorous activities (running, lifting heavy objects or participating in strenuous sports)	Physical functioning	X	X		
Limitations in moderate activities (moving a table, pushing a vacuum cleaner, bowling, playing golf)	Physical functioning	X	X		X
Limitations to lift/carry groceries	Physical functioning	X	X		
Limitations to climb several flights	Physical functioning	X	X		X
Limitations to climb one flight	Physical functioning	X	X		
Limitations to bend/kneel/stoop	Physical functioning	X	X		
Limitations to walk >1mile	Physical functioning	X	X		
Limitations to walk several blocks	Physical functioning	X	X		
Limitations to walk one block	Physical functioning	X	X		
Limitations to bathe/dress self	Physical functioning	X	X		
Health cut down time for work/activities	Role (limitations) physical	X			
Accomplished less due to health	Role (limitations) physical	X			X
Health limited work/activities	Role (limitations) physical	X			X
Difficulty performing work/activities	Role (limitations) physical	X			
Pain severity	Bodily pain	X			
Pain severity with work/activities	Bodily pain	X			
Pain interfered with work/activities	Bodily pain	X			X
Rate general health	General Health	X			X
Get sick easier than other people	General Health	X			
As healthy as anybody I know	General Health	X			
Health expected to get worse	General Health	X			
Am in excellent health	General Health	X			

SF-36 Questions	Domains	PCS	PF-10	MCS	SF-12
Proportion of time full of pep	Vitality	X		X	
Proportion of time with a lot of energy	Vitality	X		X	X
Proportion of time feeling worn out	Vitality	X		X	
Proportion of time feeling tired	Vitality	X		X	
Emotional problems cut down time for work	Role (limitations) emotional			X	
Accomplished less due to emotional problems	Role (limitations) emotional			X	X
Not as careful in work/activities as usual	Role (limitations) emotional			X	X
Health/emotional issues interfering with social activities	Social functioning			X	
Proportion of time interfering with social activities	Social functioning			X	X
Proportion of time being nervous	Mental health			X	
Proportion of time feeling down with no cheering up	Mental health			X	
Proportion of time feeling calm and peaceful	Mental health			X	X
Proportion of time feeling downhearted and blue	Mental health			X	X
Proportion of time being happy	Mental health			X	

Abbreviations: PCS = physical component subscale. MCS = Mental component subscale.

Table 2.

Commonly used physical performance tests in CKD and their association with health outcomes.

Test	Task	Population	Cut-points	Association with outcome	Studies	Resources
Physical performance						
Gait speed	Usual walking speed over 3, 4, 7, or 20 meters.	CKD ESKD	<1m/s <0.8m/s <0.6m/s (dialysis) Slowest 20th percentile of older adults in CHS by gender and height[14,45]	Mortality: Each 0.1m/s slower associated with 12% higher risk of death in older adults and 26% higher in CKD Hospitalization: <1m/s associated with 2-fold increased odds. ADL difficulty: <0.8m/s associated with 3.9-fold increased odds compared with ≥1m/s.	Roshanravan[11] Kutner[6] Johansen[45]	Normative data[59] Normograms for life expectancy by age and gait speed available[60]. Normograms for incident disability by age and gait speed[61].
Timed up and go (TUG)	Get up from seated position, walk 4 meters and return to seated position (Tests balance, walking ability, fall risk)	CKD	≥12 seconds	Mortality: 81% greater risk if 12 seconds or slower. 8% for each 1 second slower.	Roshanravan[11]	https://www.cdc.gov/steadi/pdf/tug_test-a.pdf Normative data[62]
6-minute walk distance (6MWD)	Maximal distance covered over 6 minutes. Test of functional exercise capacity	CKD ESKD	Poor exercise capacity<350 meters[63] Clinically important difference of 50 meters.	Mortality: <350meters associated with 2.8 fold increased risk of death in CKD. 11% reduction in risk of mortality for every 20 meters greater 6MWD in ESKD.	Roshanravan[11] Torino[50]	Normative data[64]
Strength						
Grip strength	Maximal grip strength using dynamometer from dominant hand or hand on non-fistula arm.	CKD ESKD Older adults	CHS (Gender and BMI based)[14] FNIH (males<26kg, females<16kg)[65]	Mortality: Weak grip associated with 79% increased risk of death in incident dialysis patients[66]	Roshanravan[11] Isoyama[66] Johansen[45]	Normative data[67]