BMC Nephrology

RESEARCH

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Association between changes of frailty status/ frailty components status and rapid loss of kidney function in middle- aged and older populations

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Abstract

Background Frailty and its components are proposed to associate with kidney function, but little attention is paid to the significance of changes in their status on rapid loss of kidney function. This study aimed to investigate the association between changes in frailty and its components status with rapid loss of renal function.

Methods This study used data from China Health and Retirement Longitudinal Study (CHARLS). Frailty status was measured using the Fried frailty phenotype (FP) scale, including five components: slowness, weakness, exhaustion, inactivity, and shrinking. Frailty status was further classified into three levels: robust (0 component), prefrail (1–2 components) and frail (3–5 components). Changes in frailty status were assessed by frailty status at baseline and 4- year follow-up. Rapid loss of kidney function was defined as a rate of estimate glomerular filtration rate(eGFR) decline ≥ 4 ml/min per 1.73 m^2per year. Logistic regression models were performed to assess the association between changes in frailty status and its components status with rapid eGFR decline.

Results A total of 2705 participants were included with 316 (11.68%) participants categorized as rapid eGFR decline during the 4-year follow-up. Compared with baseline prefrail participants who progressed to frail, prefrail participants who maintained prefrail or recovered to robust status had decreased risks of rapid eGFR decline (stable prefrail status, OR = 0.608, 95% CI: 0.396–0.953; recover to robust, OR = 0.476, 95% CI: 0.266–0.846). In contrast, among baseline robust or frail participants, we did not find changes in frailty status significantly affect the risks of rapid loss of kidney function. Moreover, participants who experienced incident weakness showed the significant relationship with an increased risk of rapid eGFR decline (OR = 1.531, 95% CI: 1.051–2.198) compared to stable non-weakness participants. Other changes of frailty components status did not significantly affect the risks of rapid eGFR decline.

Conclusions The progression of frailty status increases the risks of rapid eGFR decline among prefrail populations. Preventing weakness, may benefit kidney function.

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Keywords Frailty, Frailty components, Rapid loss of kidney function

Introduction

Frailty is a dynamic process that worsens with aging. Frailty presents with decreased functional reserve and increased susceptibility to adverse events [1]. It is associated with an increased risk of death, hospitalization and disability [2, 3]. Frailty is now a public health problem with a prevalence of 4-17% among persons older than 65 and the prevalence of frailty increases to 10–45% among individuals older than 75 [4–7]. Recently, frailty has attracted much attention from nephrologists as glomerular filtration rate (GFR)deteriorates with aging and the prevalence of frailty among people with chronic kidney disease (CKD) is higher than that among general older people [4, 8, 9]. Clarifying the association between frailty and renal impairment can provide new directions for the prevention of loss of kidney function in middle- aged and older populations.

The Fried frailty Phenotype（FP） is one of the prominent clinical measures of frailty, which includes five distinct components: slowness, weakness, exhaustion, inactivity, and shrinking. Some studies have indicated that frailty is associated with a rapid decline in kidney function [10, 11]. Previous studies have also revealed that the components of the frailty phenotype are associated with kidney function [12, 13]. The rapid loss of kidney function is associated with serious outcomes like all-cause mortality, hospitalizations, cardiovascular accidents, and renal failure among individuals with CKD [14, 15]. Furthermore, the rapid loss of kidney function also elevates the risk of all-cause mortality, cancer-related deaths, and cardiovascular deaths among the general population [16–18]. However, few studies have focused on the significance of changes in frailty status or its individual components in the rapid loss of kidney function. Frailty is a dynamic process, which can be decelerated after appropriate interventions [19–21]. Assessing the association between the rapid loss of kidney function and the progression or recovery of frailty or its components can provide important evidence for interventions on frailty.

In this study, we used data from the China Health and Retirement Longitudinal Study (CHARLS). We aimed to (1) evaluate the relationship between changes in frailty status, assessed by the Frailty Phenotype, and rapid loss of kidney function and (2) investigate the significance of changes in individual components of the Frailty Phenotype on rapid loss of kidney function.

Methods

Study population

We used data from the CHARLS, a nationally representative long-term study of Chinese people aged over 45 years old. The survey was first conducted in 2011, and followed-up was conducted every 2–3 years. Detailed descriptions of the study design and data collection procedures are available elsewhere [22]. The CHARLS was approved by the Ethics Review Committee of Peking University, and data became publicly available.

For this study, data from 2011 (baseline) and 2015 surveys were collected for analysis, because these were the only 2 waves in which blood test results were collected. In total ,17,708 participants were enrolled in 2011. People were excluded if they met the following criteria: (1) being younger than 45 years old; (2) baseline estimate glomerular filtration rate (eGFR)<60 mL/min/1.73 m2; (3) self-reported kidney disease at baseline; (4) missing eGFR in either 2011 or 2015; (5) missing data on frailty status assessment in either 2011 or 2015. Finally,2705 participants were included. The selection process is shown in Fig. 1.

Assessment of frailty status

In this study, the frailty status was measured using the Fried frailty phenotype scale. Five items were assessed in the FP, including slowness, weakness, exhaustion, inactivity, and shrinking. We adopted modified criteria, which were combined with the information available from the CHARLS and were justified as equally valid for frailty based on previous studies [23, 24]. The items of the modified criteria were as follows: (1) Slowness was defined as limitation in walking 100 m or climbing several flights of stairs without resting; (2) Weakness was determined based on the question:"having difficulty in lifting or carrying weights over 5 kg"; (3) Exhaustion was defined according to two questions from the Center for Epidemiological Studies-Depression scale: "I felt everything I did was an effort during last week" or "I could not get going during last week"; (4) Inactivity was determined if the participants did not participate in physical activity or walk at least 10 min at a time during a usual week; (5) Shrinking was defined as self-reported loss of at least 5 kg in the previous year or having a body mass index (BMI) of 18.5 kg/m2 or less. Robust was defined as participants with none of the previous criteria, prefrail was defined as participants with one or two criteria, and frail was defined as the presence of three or more criteria [25].

According to frailty status baseline and follow- up, participants were categorized into: (1) stable robust, (2) robust to prefrail/frail, (3) stable prefrail, (4) prefrail to

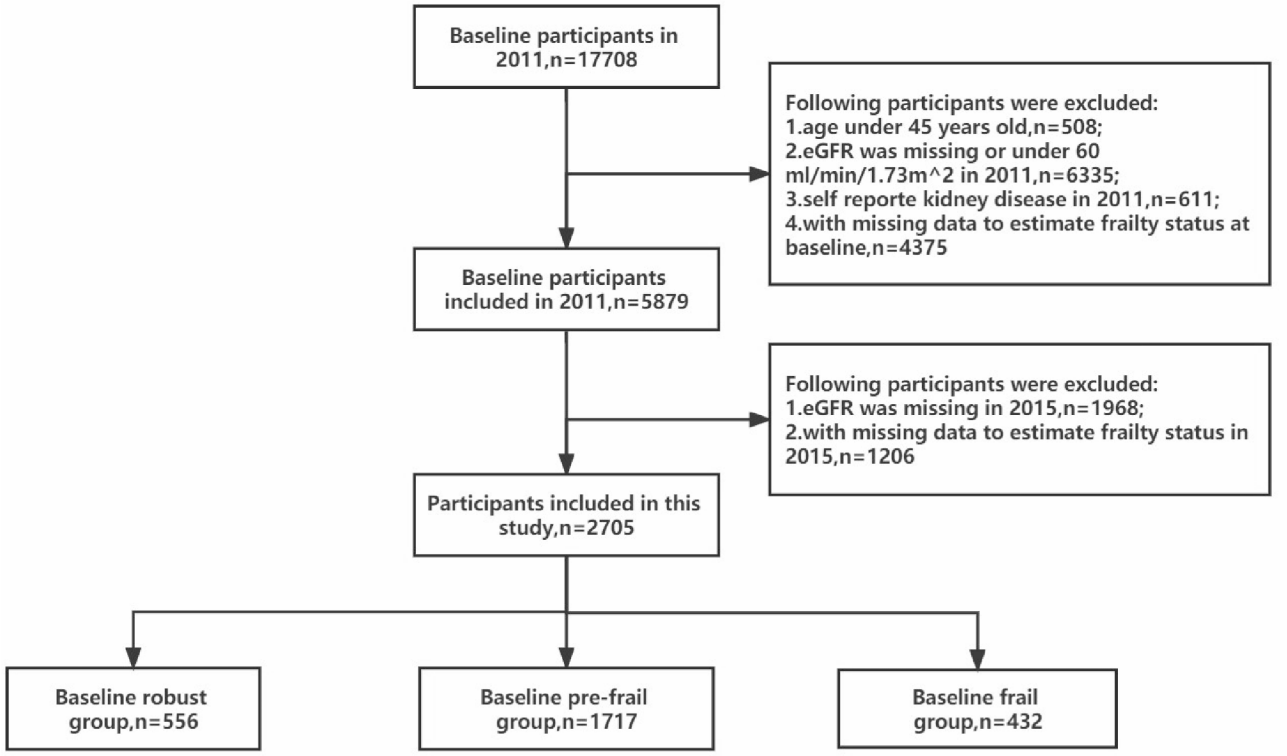

Fig. 1 Flow chart of the study population

robust, (5) prefrail to frail, (6) stable frail, and (7) frail to robust/prefrail groups.

Kidney outcome

The estimated glomerular filtration rate was assessed based on the CKD epidemiology collaboration creatinine equation [26]. The outcome was the rapid loss of kidney function. In several previous studies, a rapid progression of renal function was identified by an annual eGFR decrease exceeding 4 ml/min/1.73 m^2, and such individuals were at a significantly higher risk of adverse outcomes, including kidney failure, all-cause mortality, cardiovascular events, and all-cause hospitalization [14, 27, 28]. Accordingly, we defined rapid loss of renal function as an annual eGFR decline greater than 4 ml/min/1.73 m^2. In this study, the definition of rapid loss of renal function was a difference in the value of eGFR between the two waves exceeding 16 ml/min/1.73 m^2.

Co-variable assessment

The covariates were collected at baseline, including demographic factors (age, gender, marital status (married or partnered vs. others), education level (below primary school, primary school, middle school, high school or above), drinking status (ever drinkers vs. never drinkers), smoking status (ever smokes vs. never smokers)), laboratory indices (blood urea nitrogen, uric acid, creatinine, total cholesterol, triglycerides, low-density lipoprotein, high-density lipoprotein, high- sensitivity C reactive protein, HbA1c, eGFR continuous, eGFR group (60–89 vs.≥90)), physical indicators (BMI, blood pressure, and waist circumference) and comorbidities (anemia, hypertension, diabetes, heart disease, cancer, stroke and arthritis or rheumatism). Both systolic blood pressure (SBP) and diastolic blood pressure (DBP) were averaged from three measurements. Mean arterial pressure (MAP) was determined as 1/3×SBP+2/3×DBP. According to the World Health Organization, anemia was defined as the concentration of hemoglobin below 13 g/dL for males and below 12 g/dL for females. Other comorbidities were defined as self-reported medical history.

Statistical analysis

Categorical variables were presented as frequencies and percentages, while continuous variables were expressed as median and IQR. The comparison between groups was assessed using the $\chi 2$ test or fisher's exact test for count data. The Mann- Whitney U test was used to compare metrological data. Univariate logistic analysis was conducted to preliminarily evaluate the association between variables and the rapid loss of kidney function (Supplementary Table 1). Sex and BMI have been linked to the loss of kidney function in a community-dwelling population [29, 30]. Gender, BMI and variables with $p<0.15$ were further utilized to calibrate the multivariate logistic regression model. Tolerance<0.1 or variance inflation

factors (VIFs) > 10,were considered collinearity. Finally, age, sex, BMI, triglyceride, low-density lipoprotein, blood urea nitrogen, uric acid, eGFR, anemia and hypertension were selected as confounding variables for model adjustment, to evaluate the relationship between the changes in frailty status/frailty components and rapid decline in eGFR.

We conducted a sensitivity analysis, recalculating eGFR using the CKD Epidemiology Collaboration's cystatin C equations (eGFRcysC) to evaluate the correlation between the changes in frailty status and the rapid decline in eGFRcysC [26].

All statistical analyses were conducted using R(Version 4.2.3). *P* values less than 0.05 were considered statistically significant (two- sided test).

Results

Characteristics of the study population

Based on the inclusion and exclusion criteria,2705 participants were included comprising 237 (8.76%) participants in the stable robust group, 319 (11.79%) participants in the robust to prefrail/frail group, 1167 (43.14%) participants in the stable prefrail group, 318 (11.76%) participants in the prefrail to robust group,232 (8.58%) participants in the prefrail to frail group,186 (6.88%) participants in the stable frail group and 246(9.09%) participants in the frail to robust/prefrail group. Stratified based on eGFR decline rate, baseline characteristics of the study population are shown in Table 1. There were 1132 males (41.85%), the overall median age was 59 years (IQR: 53–65). A rapid loss of kidney function was observed in 316 (11.68%) participants during the 4-year follow-up period. Compared to the non-rapid eGFR decline group, the rapid eGFR decline group had significantly higher age, uric acid levels, eGFR and prevalence of anemia (all $p<0.05$). Conversely, higher low-density lipoprotein or serum creatinine levels were observed in participants of the non- rapid eGFR decline group ($p<0.05$).

Association of baseline frailty status with rapid eGFR decline

Supplementary Table 2 presents the association of baseline frailty status with the rapid loss of kidney function. After adjustment for age, gender and BMI (Model 1) or for age, gender, BMI, triglyceride, low-density lipoprotein, blood urea nitrogen, uric acid, eGFR, anemia and hypertension (Model 2), there was no significant relationship between baseline prefrail status and the risk of rapid eGFR decline compared to baseline robust status. In contrast, baseline frail participants had a significantly increased risk of rapid loss of kidney function compared to baseline robust participants in both Model 1 (OR = 1.618, 95% CI: 1.078–2.434, $P=0.020$) and Model 2 (OR = 1.543, 95% CI: 1.007–2.371, $P=0.047$).

Association of changes in frailty status with rapid decline in eGFR

The relationship of changes in frailty status with rapid decline in eGFR is shown in Table 2. For baseline prefrail participants, those who recovered to robust status (Model 1:OR = 0.500, 95% CI: 0.287–0.865, $P=0.013$;Model 2: OR = 0.476, 95% CI: 0.266–0.846, $P=0.012$) or those with stable prefrail status (Model 1:OR = 0.644, 95% CI: 0.428–0.988, $P=0.039$;Model 2: OR = 0.608, 95% CI: 0.396–0.953, $P=0.026$) showed significantly decreased risks of rapid eGFR decline compared to those who progressed to the frail status. After adjustment for confounders, there was no significant relationship between the changes in frailty status and rapid eGFR decline in either baseline robust group (robust to prefrail/frail vs. stable robust) or baseline frail group (frail to robust/prefrail vs. stable frail).

We observed consistent results when using the cystatin C equation to reassess eGFR (Supplementary Table 3). Compared to the progression of the frailty status, recovery from the prefrail status or maintaining a stable prefrail status was associated with a reduced risk of rapid kidney function decline in the baseline prefrail group. However, no significant relationship was observed between changes in frailty status and rapid eGFRcysC decline in the baseline robust or frail groups.

Association of changes in frailty components status with rapid eGFR decline

The association of changes in the status of frailty components, including slowness, weakness, exhaustion, inactivity, and shrinking, with rapid eGFR decline is shown in Table 3. In the population without corresponding frailty component at baseline, participants with developed weakness had significantly higher risks of rapid loss of kidney function compared to stable non-weakness population (Model 1:OR = 1.540, 95% CI: 1.073–2.177, $P=0.017$;Model 2: OR = 1.531, 95% CI: 1.051–2.198, $P=0.023$), whereas developed slowness, exhaustion, inactivity and shrinking did not show significant differences compared to the corresponding population (all $p>0.05$). In the population with corresponding frailty component at baseline, we observed no significant differences in the rapid loss of kidney function between recovery groups and corresponding contrast groups (all $p>0.05$).

Discussion

In this study, we investigated the relationship between baseline frailty status, changes in frailty status or changes in the status of frailty components with rapid loss of kidney function. We found that baseline frail participants had significantly elevated risks of rapid eGFR decline compared to baseline robust participants. At 4- year follow- up, only among baseline prefrail participants,

Table 1 Characteristics of participants between rapid eGFR decline group and non- rapid eGFR decline group

Characteristics	Overall	Non-Rapid eGFR decline	Rapid eGFR decline	*p* value
	(*n* = 2705)	(*n* = 2389)	(*n* = 316)	
Age (years)	59 (53,65)	59 (53,65)	61 (52,68)	**0.035**
Male(n(%))	1,132(41.85%)	990 (41.44%)	142(44.94%)	0.261
Marital status(n(%))				0.814
Married or partnered	2,399 (88.69%)	2,117 (88.61%)	282 (89.24%)	
Other marital status	306 (11.31%)	272 (11.39%)	34 (10.76%)	
Educational level(n(%))				0.962
Below primary school	1,363 (50.43%)	1,205 (50.46%)	158 (50.16%)	
Primary school	631 (23.34%)	557 (23.32%)	74 (23.49%)	
Middle school	486 (17.98%)	427 (17.88%)	59 (18.73%)	
High school or above	223 (8.25%)	199 (8.33%)	24 (7.62%)	
Smoking status(n(%))				0.696
Never smokers	1,726 (63.81%)	1,528 (63.96%)	198 (62.66%)	
Ever smokers	979 (36.19%)	861 (36.04%)	118 (37.34%)	
Drinking status(n(%))				0.340
Never drinkers	1,696 (62.72%)	1,506 (63.07%)	190 (60.13%)	
Ever drinkers	1,008 (37.28%)	882 (36.93%)	126 (39.87%)	
Blood urea nitrogen (mg/dL)	14.93 (12.49, 17.84)	14.87 (12.46, 17.81)	15.39 (12.76, 18.01)	0.120
Uric acid (mg/dL)	4.18 (3.50, 5.04)	4.16 (3.49, 5.02)	4.36 (3.60, 5.15)	**0.032**
Creatinine (mg/dL)	0.73 (0.63, 0.85)	0.73 (0.64, 0.85)	0.72 (0.61, 0.84)	**0.011**
Total cholesterol (mg/dL)	190.98 (167.01, 216.88)	191.75 (167.40, 216.88)	187.31 (164.98, 218.43)	0.295
Triglyceride (mg/dL)	105.32 (75.22, 152.22)	105.32 (75.22, 151.34)	106.20 (72.35, 157.97)	0.880
LDL cholesterol (mg/dL)	114.82 (92.78, 137.63)	115.98 (93.94, 138.02)	110.95 (87.37, 132.99)	**0.010**
HDL cholesterol (mg/dL)	49.48 (40.59, 60.31)	49.87 (40.98, 59.92)	47.94 (39.43, 61.57)	0.516
hs - CRP (mg/L)	1.02 (0.53, 2.13)	1.01 (0.53, 2.14)	1.08 (0.54, 1.99)	0.834
HbA1c (%)	5.10 (4.90, 5.40)	5.10 (4.90, 5.40)	5.10 (4.80, 5.40)	0.785
eGFR(mL/min/1.73 m2)	95.47 (86.06, 102.58)	95.41 (85.77, 102.35)	95.67 (87.51, 105.32)	**0.036**
eGFR group (n (%))				0.657
60 ~ 89 mL/min/1.73 m2	916 (33.86%)	813 (34.03%)	103 (32.59%)	
90 ~ mL/min/1.73 m2	1,789 (66.14%)	1,576 (65.97%)	213 (67.41%)	
Body mass index (kg/m2)	23.25 (20.92, 25.94)	23.23 (20.96, 25.90)	23.28 (20.67, 26.26)	0.959
Waist circumference (cm)	84.80 (78.00, 92.10)	84.80 (78.00, 92.00)	84.55 (78.00, 93.28)	0.761
Systolic blood pressure (mm Hg)	126.33 (113.33, 141.67)	126.33 (113.33, 141.67)	128.67 (113.00, 143.33)	0.378
Diastolic blood pressure (mm Hg)	74.33 (67.00, 82.67)	74.67 (67.33, 82.67)	73.67 (65.33, 82.00)	0.400
Mean arterial pressure (mm Hg)	91.89 (83.00, 101.67)	91.89 (83.00, 101.67)	92 (82.56, 102.44)	0.947
Anemia (n (%))	321 (12.09%)	270 (11.50%)	51 (16.61%)	**0.013**
Hypertension (n (%))	772 (28.70%)	669 (28.16%)	103 (32.80%)	0.100
Diabetes or HBG (n (%))	186 (6.96%)	164 (6.95%)	22 (7.01%)	> 0.999
Heart problem (n (%))	343 (12.79%)	303 (12.80%)	40 (12.74%)	> 0.999
Stroke (n (%))	64 (2.38%)	56 (2.35%)	8 (2.54%)	0.996
Cancer (n (%))	26 (0.97%)	23 (0.97%)	3 (0.95%)	> 0.999
Arthritis or rheumatism (n (%))	1,012 (37.47%)	886 (37.15%)	126 (39.87%)	0.380
Baseline frailty status (n (%))				0.071
Robust	556 (20.55%)	501 (20.97%)	55 (17.41%)	
Pre-frail	1,717 (63.48%)	1,519 (63.58%)	198 (62.66%)	
frail	432 (15.97%)	369 (15.45%)	63 (19.94%)	
Baseline robust group (n (%))				0.555
Stable robust	237 (42.63%)	211 (42.12%)	26 (47.27%)	
Robust to pre-frail/frail	319 (57.37%)	290 (57.88%)	29 (52.73%)	
Baseline pre-frail group (n (%))				0.066
Pre-frail to frail	232 (13.51%)	196 (12.90%)	36 (18.18%)	
Stable pre-frail	1,167 (67.97%)	1,034 (68.07%)	133 (67.17%)	
Pre-frail to robust	318 (18.52%)	289 (19.03%)	29 (14.65%)	

Table 1 (continued)

Characteristics	Overall	Non-Rapid eGFR decline	Rapid eGFR decline	*p* value
	(*n* = 2705)	(*n* = 2389)	(*n* = 316)	
Baseline frail group (n (%))				0.918
Stable frail	186 (43.06%)	158 (42.82%)	28 (44.44%)	
Frail to robust/pre-frail	246 (56.94%)	211 (57.18%)	35 (55.56%)	

Abbreviations: eGFR, estimated glomerular filtration rate.; LDL, low-density lipoprotein; HDL, high-density lipoprotein; hs-CRP, high- sensitivity C reactive protein; HBG, high blood glucose

The bold values indicate $p<0.05$

Missing values for total study: BMI ($n=99$; 3.66%), educational level ($n=2$; 0.07%), drinking status ($n=1$; 0.04%), low-density lipoprotein ($n=5$;0.18%), HbA1c % ($n=19$,0.70%),waist circumference ($n=94$,3.48%),blood pressure ($n=107$,3.96%), anemia ($n=50$; 1.85%),hypertension ($n=15$,0.55%),diabetes or HBG ($n=31$; 1.15%), heart diseases ($n=23$; 0.85%),stroke ($n=12$;0.44%), cancer ($n=18$; 0.67%), arthritis or rheumatism ($n=4$; 0.15%)

Table 2 Association of changes in frailty status with rapid eGFR decline

	Model 1		Model 2	
	Adjusted OR (95% CI)	*P* value	Adjusted OR (95% CI)	*P* value
Baseline robust group				
Stable robust	reference		reference	
Robust to pre-frail/frail	0.864(0.489,1.535)	0.615	0.854(0.464,1.579)	0.611
Baseline pre-frail group				
Pre-frail to frail	reference		reference	
Stable pre-frail	0.644(0.428,0.988)	**0.039**	0.608(0.396,0.953)	**0.026**
Pre-frail to robust	0.500(0.287,0.865)	**0.013**	0.476(0.266,0.846)	**0.012**
Baseline frail group				
Stable frail	reference		reference	
Frail to robust/pre-frail	1.147(0.641,2.077)	0.647	1.349(0.733,2.526)	0.341

Model 1: additional adjusted for age, sex and body mass index

Model 2: additional adjusted for age, sex, body mass index, triglyceride, low-density lipoprotein, uric acid, blood urea nitrogen, eGFR, anemia and hypertension

Abbreviations: eGFR, estimated glomerular filtration rate

The bold values indicate $p<0.05$

Table 3 Association of changes in frailty components status with rapid eGFR decline

	Model 1		Model 2	
	Adjusted OR (95% CI)	*P* value	Adjusted OR (95% CI)	*P* value
Participants with the corresponding frailty component at baseline				
Recovery of frailty component (stable status with the corresponding frailty component as reference)				
weakness	1.071(0.560,2.050)	0.835	1.090(0.551,2.162)	0.804
slowness	1.011(0.688,1.464)	0.955	1.004(0.671,1.480)	0.983
exhaustion	1.049(0.740,1.487)	0.789	1.026(0.717,1.468)	0.888
inactivity	0.949(0.177,7.431)	0.954	1.330(0.140,18.286)	0.811
shrinking	1.122(0.489,2.578)	0.786	0.974(0.398,2.373)	0.953
Participants without the corresponding frailty component at baseline				
Progression of frailty component (stable status without the corresponding component as reference)				
weakness	1.540(1.073,2.177)	**0.017**	1.531(1.051,2.198)	**0.023**
slowness	0.782(0.528,1.144)	0.211	0.743(0.493,1.105)	0.148
exhaustion	1.296(0.895,1.855)	0.162	1.270(0.859,1.853)	0.222
inactivity	1.007(0.521,1.805)	0.981	0.953(0.463,1.790)	0.887
shrinking	1.818(0.949,3.268)	0.056	1.735(0.892,3.171)	0.087

Model 1: additional adjusted for age, sex and body mass index

Model 2: additional adjusted for age, sex, body mass index, triglyceride, low-density lipoprotein, uric acid, blood urea nitrogen, eGFR, anemia and hypertension

Abbreviations: eGFR, estimated glomerular filtration rate

The bold values indicate $p<0.05$

the progression of frailty status was significantly associated with increased risks of rapid loss of kidney function compared to stable prefrail status or recovery of frailty status. The same trend was not found in baseline robust participants or baseline frail participants. Moreover, participants who experienced incident weakness showed a significant relationship with increased risks of rapid decline in eGFR, regardless of being classified as frail overall. The incidence of other components of frailty or recovery of frailty components did not significantly affect the risk of rapid decline in eGFR.

A 3- year large cohort study showed that baseline frail status was associated with increased risks of rapid eGFR decline compared to robust status [10]. In our study, we observed consistent results for elevated risks of rapid eGFR decline among frail participants compared to robust participants. In a cohort with 358 participants, Shi et al. found that the value of eGFR decline was the highest in the frail group among all three baseline frailty groups (robust, prefrail, and frail). Although the magnitude of eGFR decline did not meet the criteria of rapid loss of kidney function adopted by our study [11]. The sample size of this study was much smaller than other studies. Our findings supported that baseline frail status is an independent risk factor for rapid decline in kidney function.

As far as we know, few studies have focused on the significance of the changes in frailty status or the status of its individual components on rapid eGFR decline. A clinical trial demonstrated that appropriate intervention can improve frailty parameters [31]. Our study also confirmed that frailty is a dynamic status. More importantly, we found that among baseline prefrail participants, the progression of frailty status was significantly associated with an increased risk of rapid loss of kidney function compared to stable prefrail status or recovery of frailty status. This finding highlighted the adverse effects of frailty progression and the positive effect of frailty recovery on eGFR. In our study, the risks of rapid loss of kidney function did not increase among robust participants who progressed to prefrail/frail status and did not decrease in frail participants who recovered to prefrail/robust status. In contrast, a previous study found that a rapid eGFR decline is associated with incident frailty (robust/prefrail to frail) in community-dwelling older adults [32]. We need to be cautious about the conclusion on the associations between the changes in frailty status and the rapid decline in eGFR among baseline robust and frail participants. Since the follow- up time was short, the effect of changes in frailty status might not have occurred in some populations. Longer follow- up is needed to elucidate the associations between frailty status dynamics and the rapid loss of kidney function.

We found that participants who experienced incident weakness showed a significant increase in the risk of rapid eGFR decline. Decreased muscle strength may be associated with rapid loss of kidney function. Previous studies reported that weak muscle strength increases the risk of kidney function decline and rapid kidney function decline [33, 34]. However, the assessment of muscle strength came from baseline data. We focused on the associations between the incidence or recovery of low muscle strength and rapid eGFR decline, which received less attention in previous studies. Our study found that the progression of weakness increased the risk of rapid eGFR decline, but recovery of weakness did not decrease the risk of rapid eGFR decline. A randomized controlled exercise intervention indicated that appropriate training may be a promising strategy to promote muscle strength, and can prevent the decrease in eGFR [35]. It may help guide the management of eGFR decline in a community-dwelling population. Regrettably, our study could not provide the accurate threshold value of muscle strength to define weakness. Although we did not find a relationship between changes in other frailty components and rapid eGFR decline, some studies indicated that many components of the frailty phenotype were associated with kidney function [12, 13]. The effect of frailty on kidney function is complex, thus, no definitive mechanisms can warrant our findings. Our study provides important preliminary data for future studies.

To the best of our knowledge, this is the first study to investigate the relationship between the changes in frailty status/frailty components status and rapid loss of kidney function. However, there were some limitations to our study. First, our study could not establish a cause-and-effect relationship since blood samples were collected only at baseline and during the 2015 survey, which precluded the assessment of changes in frailty status before outcome evaluations. Further studies are needed to ascertain the causal association between the changes in frailty status and the rapid decline in kidney function. Second, although we adjusted for multiple confounders, residual confounding factors might remain unadjusted. Third, our definition of frailty was based on self-reported physical function rather than direct measurement of physical performance. Although it is convenient to implement, it may lead to potential bias. Fourth, we did not establish a model comprising all seven frailty change groups included in the study.

Conclusions

Our findings suggested that, among the prefrail population, the progression of frailty may play an essential role in rapid eGFR decline. Preventing weakness, may benefit kidney function. The findings of this study may be helpful for preventing rapid eGFR decline.

Abbreviations

GFR	Glomerular filtration rate
CKD	Chronic kidney disease
CHARLS	China Health and Retirement Longitudinal Study
eGFR	Estimated glomerular filtration rate
FP	Fried frailty phenotype
BMI	Body mass index
SBP	Systolic blood pressure
DBP	Diastolic blood pressure
MBP	Mean arterial pressure
VIFs	Variance inflation factors
eGFRcysC	The cystatin C-based eGFR equation
CI	Confidence interval
OR	Odds ratio
IQR	Interquartile range

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12882-024-03744-2.

Supplementary Material 1: Supplemental Table 1 Univariate logistic analysis of variables between eGFR rapid decline group and non- rapid eGFR decline group. Supplemental Table 2 Association of baseline frailty status with rapid eGFR decline. Supplemental Table 3 Association of changes in frailty status with rapid eGFR(eGFRCysC) decline.

Acknowledgements

We thank the China Center for Economic Research, the National School of Development of Peking University for providing the data.

Author contributions

YD, JHL and LLT contributed equally to this work. YD, JHL, LLT, SML, XHG, JHK and XL contributed to the research idea and analysis plan. YD, JHL and LLT contributed to study design and data collection. YD and JHL contributed data analysis. YD, JHL and LLT contributed to the manuscript preparation from drafting to revision. YD was a major contributor to the manuscript writing. YD, JHL, LLT, SML, XHG, JHK and XL were involved in supervision/mentorship. All authors read and approved the final manuscript.

Funding

This work was supported by the Natural Science Foundation of China (Grant No.81873631, 81370866, 81070612),the Guangzhou Science and technology planning project (Grant No.202002020047) and NSFC-Guangdong United Fund (Grant No. 2020B1515120037). The funder had no role in study design, data collection/analysis/interpretation or manuscript preparation.

Data availability

The datasets use in this study are publicly available at http:// charls. pku. edu. cn.

Declarations

Ethics approval and consent to participate

The CHARLS was approved by the Ethics Review Committee of Peking University(IRB00001052-11015),and informed consent was obtained from each subject in this cohorts. As this study was a secondary analysis of the data, review and approval was not required for this research by the authors' institutional review board or ethics committee.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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Received: 25 July 2024 / Accepted: 4 September 2024
Published online: 13 September 2024

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