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CLINICAL RESEARCH

Associations of sarcopenic obesity vs either sarcopenia or obesity alone with cognitive impairment risk in patients requiring maintenance hemodialysis

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Abstract

Background: The association between sarcopenic obesity (SO) and cognitive impairment (CI) risk in patients requiring maintenance hemodialysis (MHD) is not known. In this study, we investigated the prevalence of SO in MHD patients. Furthermore, we would explore and compare the associations between SO, sarcopenia, and obesity with CI risk in this population.

Methods: A multicenter, cross-sectional study was conducted. Data from 2743 adult MHD patients were recorded. SO was defined as the co-occurrence of sarcopenia and obesity. Cognitive function was assessed with the Mini-Mental State Examination (MMSE). Multiple logistic regression models, stratified analyses, and interactive analyses were conducted.

Results: 21.58% of the participants met the criteria for SO. The overall prevalence of CI was 23.3% in our study. Participants in the SO group had the highest CI prevalence (34.6%). The association between SO and CI was weakened but remained statistically significant after adjusting for age, sex, and educational status (odds ratio, 1.47; 95% CI, 1.11–1.96). However, associations between sarcopenia, obesity, and CI disappeared after adjusting for these variables. The additional adjustment did not attenuate the significant association between SO and CI. Subgroup analyses and interactive analyses showed that the associations were similar across subgroups ($P > 0.05$ for interaction for all).

Conclusions: SO and CI are highly prevalent in MHD patients. Participants with SO are at significantly higher risk of CI than those with sarcopenia or obesity alone. Furthermore, this association is consistent across different subgroups.

KEYWORDS
bioelectrical impedance analysis, cognitive impairment, hemodialysis, obesity, sarcopenia

Abbreviations: BMI, body mass index; CI, cognitive impairment; MHD, maintenance hemodialysis; MMSE, Mini-Mental State Examination; SO, sarcopenic obesity..

INTRODUCTION

Sarcopenia, characterized by loss of skeletal muscle mass and function, is highly prevalent in maintenance hemodialysis (MHD) patients. Sarcopenia is often overlooked in obese patients, as it appears that malnourished patients or patients who exhibit a low body mass index (BMI) are much more prone to have sarcopenia. Sarcopenia can coexist with obesity, which has been termed sarcopenic obesity (SO). SO has gained increasing attention in recent years, especially in the older adults and patients with chronic diseases as populations get older and the prevalence of obesity is increasing.[1] Accordingly, the influence of SO on dialysis patients has become a growing concern.[2,3] Previous studies have suggested that SO is a stronger predictor of cardiovascular disease and physical function deterioration than either sarcopenia or obesity alone.[4,5] However, this may not necessarily apply to MHD patients as higher body fat seems to be protective and MHD patients with higher body fat have a more favorable clinical prognosis,[6] which is known as the "obesity paradox." It is reported that MHD patients with SO had better prognosis for cardiovascular events, all-cause and cardiovascular disease mortality compared with those with sarcopenia alone.[7]

Cognitive impairment (CI) is a common and disabling condition in MHD patients.[8] Either sarcopenia or obesity is associated with an increased risk of CI in the general population.[9] Patients with SO are expected to have a heightened risk of CI compared with those with sarcopenia or obesity alone. Indeed, several studies have reported that SO is associated with a significantly higher risk of CI compared with sarcopenia or obesity alone in older community-dwelling individuals.[10] However, these associations were not observed in community-dwelling adults according to a recent study.[11] The association between SO and CI risk may vary in different populations and need to be ascertained in MHD patients due to the lack of previous studies in this population.

Thus, the purpose of this study was to investigate the prevalence of SO in MHD patients. Furthermore, we would evaluate and compare the associations between SO, sarcopenia, and obesity alone with CI risk in this population.

MATERIALS AND METHODS

Participants

As described in our previous studies,[12] we conducted a multicenter, cross-sectional study in GuiZhou province, Southwest China between June 1, 2020, and September 30, 2020. All adult patients undergoing hemodialysis in 20 hemodialysis centers in GuiZhou were invited to participate in our study. Participants were excluded from the study if they met the following criteria: (1) patients who received regular dialysis for <3 months; (2) had visual or hearing or mental disabilities; (3) had language barriers; (4) had any physical deformities; (5) were younger than 18 years; (6) unable to provide informed consent; (7) had an excessive volume load, such as those with ongoing heart failure, (8) did not have routine blood tests in the past 3 months.

This study was approved by the ethics committee of Gui Zhou provincial people's hospital. Informed written consent was obtained from all study participants or their immediate family members before our study.

Data collection

Sociodemographic and medical data including age, sex, duration of hemodialysis, educational status, personal situation, lifestyle variables, and comorbid conditions were obtained in face-to-face interviews using structured questionnaires. Patients with no formal education and those with senior in middle school and below education were assigned to the lower educational status group. Participants with high school and above education were assigned to the higher educational status group. All MHD patients would have a routine blood test at least once every 3 months. The most recent laboratory parameters such as serum creatinine (Scr) levels, serum uric acid levels, and total protein were collected from the medical records, which were measured during routine blood tests. All blood tests came from fasting blood samples collected during the interdialysis period.

Anthropometric and body composition measurement

Weight was measured with an electronic scale to the nearest 0.10 kg, whereas height was measured via a stadiometer to the nearest 0.10 cm, with participants barefoot and wearing lightweight clothes. BMI was calculated from self-reported dry weight and the measured height. Grip strength was acquired by trained renal physicians by taking two readings from the nonfistula hand using a handheld dynamometer (CAMRY EH101). The maximal score was recorded. For participants with an indwelling dialysis catheter, a single trial for each hand was tested and the maximal score was used in the final analyses.

A portable whole-body bioimpedance spectroscopy device, the body composition monitor (Fresenius Medical

Care) was used to evaluate the total body water, lean tissue mass, and adipose tissue mass of the participants. Body composition analysis was performed on the current weight. Appendicular skeletal muscle mass was calculated according to an equation developed in MHD patients recently.[12] The appendicular skeletal muscle mass index was then calculated according to the following equation: The appendicular skeletal muscle mass index (in kilogram per meter squared) = appendicular skeletal muscle mass/height squared.

Assessment of sarcopenia, obesity, and SO

According to the Asian Working Group for Sarcopenia, sarcopenia is defined as low grip strength (defined as handgrip strength <26 kg in males and <18 kg in females) plus low muscle mass (defined as appendicular skeletal muscle mass index <7.0 kg/m^2 in men and <5.7 kg/m^2 in women). To date, there is no consensus definition of SO. To exclude the effect of fluid overload, we use the percentage of body fat (FAT%) to define obesity. According to a recent study,[13] obesity was defined as FAT% >35% in women and FAT% >30% in men in our study, and FAT% was calculated as total body fat mass divided by total mass multiplied by 100.[14] SO was defined as the co-occurrence of sarcopenia and obesity.

Assessment of cognitive function

The Chinese version of the Mini-Mental State Examination (MMSE) score was used to evaluate the cognitive function of the participants by trained physicians and nurses. All the physicians and nurses received intensive training from neuropsychologists to conduct the assessments before the study was initiated. Participants with MMSE scores <27 were considered cognitively impaired according to previous studies.[15,16]

Statistical analysis

Statistical analyses were performed with SPSS statistical software version 23.0 (IBM Corporation). A two-tailed P value <0.05 was considered significant in all analyses. Participants were categorized into four groups according to the presence or absence of sarcopenia or obesity, namely, sarcopenia, obesity, SO, and nonsarcopenic and nonobese group. Characteristics of the participants in different groups were described with mean ± standard deviation (SD) (normally distributed) or median with interquartile range (skewed distribution) for continuous variables. Categorical variables were presented as percentages and analyzed with chi-square with Bonferroni correction for multiple testing. One-way analysis of variance or Kruskal-Wallis test was used to compare continuous variables depending on the distribution of variables. The further pairwise comparison between multiple groups in the normal distribution data were performed by SD t test. Multiple logistic regression models were used and the odds ratios (ORs) and 95% CIs were calculated to evaluate the association between SO and CI, with CI as the dependent variable, and the nonsarcopenic and nonobese group as the reference group. Four models were used to analyze the association between SO and CI risk: Model 1 (unadjusted model), Model 2 (adjusting for age, sex, and educational status), Model 3 (adjusting for confounders in Model 2 as well medical history such as hypertension, diabetes, stroke, and current smoking + current drinking). As dialysis vintage (length of time on dialysis) is related to CI, dialysis vintage was adjusted in Model 4. Age, sex, educational status, diabetes status, and hypertension were reported to have a possible effect on cognitive function.[17,18] To evaluate the robustness of the association between SO and CI, we further performed subgroup analyses. Educational status was divided into two groups: lower educational status (senior in middle school and below) and higher educational status (high school and above).

RESULTS

Baseline characteristics

A total of 3320 participants took part in our study initially, and 577 were excluded due to missing data on MMSE score, grip strength, FAT%, and appendicular skeletal muscle mass index. Adult patients (2743) with a median age of 55 (44–66) years were analyzed finally in our study. Among the 2743 patients, 1603 participants were men and 1140 participants were women. Participants were divided into four groups based on the presence or absence of sarcopenia or obesity. Table 1 presents each group's baseline characteristics. Participants in the SO group were significantly older and were more likely to report a history of stroke and diabetes than participants in the other groups ($P < 0.001$). No statistically significant difference was observed regarding the dialysis vintage, educational status, current alcohol use, and self-reported history of hypertension among the four groups. Participants in the SO group had a lower lean tissue mass, grip strength, Scr levels, and appendicular skeletal muscle mass index compared with patients in other groups ($P < 0.001$).

TABLE 1 Patients' basic characteristics of different groups.

Variables	Total, $n = 2743$	Sarcopenic obesity, $n = 592$	Sarcopenia, nonobesity, $n = 429$	Obesity, nonsarcopenic, $n = 847$	Nonsarcopenic and nonobesity, $n = 875$	*P*
Age, years, median, (IQR)	55.0 (44.0–66.0)	65.0 (56.0–73.0)	57.0 (48.0–69.0)	54.0 (45.0–63.0)	47.0 (37.0–57.0)	<0.001
Sex, male, *n* (%)	1603 (58.4)	351 (59.3)	261 (60.8)[c]	444 (52.4)[b,d]	547 (62.5)[c]	<0.001
Lean tissue mass, kg, median, (IQR)	38.7 (32.6–44.9)	31.3 (27.0–36.2)[b,c,d]	38.3 (34.0–42.8)[a,d]	37.6 (32.0–43.4)[a,d]	45.6 (39.8–52.2)[a,b,c]	<0.001
Cognitive impairment, *n* (%)	638 (23.3)	205 (34.6)[b,d]	111 (25.9)[a,d]	186 (22)[a,d]	136 (15.5)[a,b,c]	<0.001
Educational status, graduated high school, *n* (%)	779 (29.3)	156 (27.3)	115 (27.7)	251 (30.3)	257 (30.3)	0.497
Current cigarette user, *n* (%)	642 (23.5)	131 (22.3)	104 (24.5)	166 (19.6)[d]	241 (27.7)[c]	0.001
BMI, kg/m^2, mean ± SD	22.7 ± 3.6	22.1 ± 2.5[b,c]	19.2 ± 1.8,[a,c,d]	25.6 ± 3.4,[a,b,c]	21.9 ± 3.0[b,c]	<0.001
Dialysis vintage, months, median (IQR)	42.0 (19.0–74.0)	43.0 (20.0–75.0)	40.0 (18.5–73.5)	42.0 (22.0–73.0)	38.0 (18.0–73.0)	0.21
Serum creatinine level, μmol/L, median, (IQR)	921.4 (733.8–1130.0)	800.9 (633.0–978.6)	861.2 (666.8–1066.0)	930.0 (762.5–1111.0)	1054.0 (841.0–1240.0)	<0.001
Waist circumference, cm, median, (IQR)	83.0 (75.0–90.5)	84.0 (78.0–90.0)	74.0 (70.0–80.0)	90.0 (83.0–97.9)	79.0 (73.0–86.0)	<0.001
Serum uric acid level, μmol/L, median, (IQR)	440.0 (373.0–514.6)	425.5 (368.6–494.3)	421.0 (355.5–494.0)	453.0 (387.6–523.7)	445.6 (376.8–518.9)	<0.001
Handgrip strength, kg, median, (IQR)	20.0 (14.5–27.0)	15.0 (11.0–20.0)[c,d]	15.0 (12.0–20.0)[c,d]	23.0 (17.0–29.0)[a,b,d]	26.0 (19.0–32.0)[a,b,c]	<0.001
Current alcohol user, *n* (%)	143 (5.2)	26 (4.4)	21 (4.9)	48 (5.7)	48 (5.5)	0725
History of hypertension, *n* (%)	2088 (77.7)	454 (78)	320 (76.9)	632 (76.2)	682 (79.3)	0.48
History of diabetes, *n* (%)	771 (30.6)	242 (43.7)[b,c,d]	106 (27.2)[a,d]	264 (33.7)[a,d]	159 (20)[a,b,c]	<0.001
Fat tissue mass, kg, median, (IQR)	18.7 (11.9–26.4)	23.7 (20.0–29.5)[b,c,d]	11.1 (7.4–13.9)[a,c]	27.3 (22.8–32.7)[a,b,d]	11.8 (7.4–15.7)[a,c]	<0.001
History of stroke, *n* (%)	245 (9.2)	80 (13.7)[b,d]	32 (7.8)[a]	76 (9.3)	57 (6.7)[a]	<0.001
ASMI, kg/m^2, median, (IQR)	6.3 (5.6–7.1)	5.6 (5.0–6.3)[c,d]	5.7 (5.1–6.4)[c,d]	6.7 (6.1–7.4)[a,b]	6.8 (6.0–7.4)[a,b]	0.001
FAT%, median, (IQR)	32.85 (22.33–42.51)	42.58 (36.74–48.86)[b,c,d]	22.87 (15.14–27.90)[a,c]	41.83 (36.67–48.07)[a,b,c]	20.99 (13.51–26.57)[a,c]	<0.001

Note: *P* values refer to comparisons among all four groups. Pairwise comparisons between the four groups were statistically significant. The alphabetic footnotes a, b, c, and d represent the sarcopenic obesity, sarcopenia (nonobesity), obesity (nonsarcopenic), nonsarcopenic and nonobesity group, respectively, and the group with a letter represents that there was statistically significant difference between the groups.

Abbreviations: ASMI, appendicular skeletal muscle mass index; BMI, body mass index; FAT%, percentage of body fat; IQR, interquartile range.

[a]There is statistical difference compared with sarcopenic obesity group.

[b]There is statistical difference compared with sarcopenic nonobesity group.

[c]There is statistical difference compared with obesity nonsarcopenic group.

[d]There is statistical difference compared with nonsarcopenic nonobesity group.

Prevalence of SO and CI

As shown in Figure 1, among the 2743 patients, a total of 592 (21.58%) participants met the criteria of SO, 429 (15.64%) participants were diagnosed with sarcopenia, 847 (30.88%) participants had obesity only, whereas 875 (31.9%) participants were assigned to the nonsarcopenia and nonobese group. The overall prevalence of CI was 23.3% (638), and the prevalence of CI differed significantly ($P < 0.001$) among different groups, with those in the SO group having the highest prevalence (34.6%).

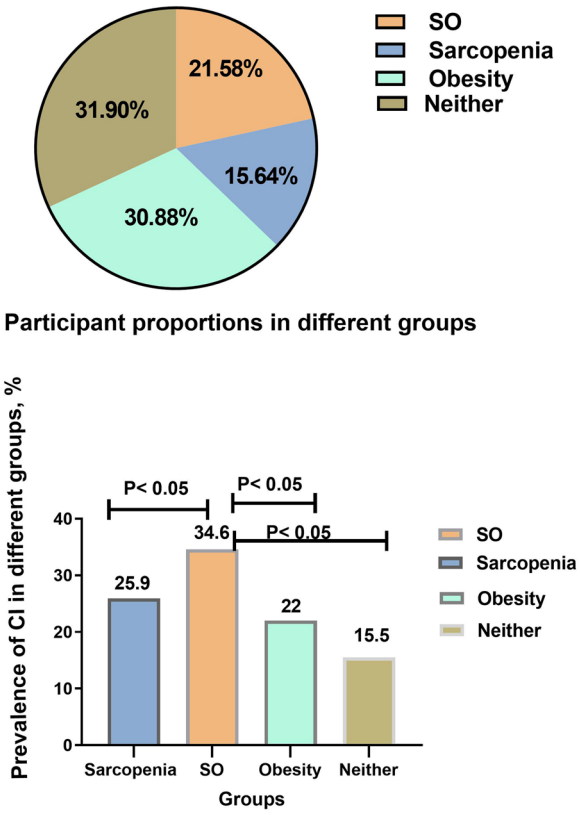

FIGURE 1 Participant proportions in different groups and the prevalence of cognitive impairment in different groups (both in percentages). SO, sarcopenia obesity.

Association between SO, sarcopenia alone, and CI risk

As shown in Table 2, SO, sarcopenia, and obesity were associated with increased risk of CI in unadjusted models. Participants with SO had a higher CI risk than those with sarcopenia or obesity alone (unadjusted OR [95% CI] was 2.88 [2.24–3.69], 1.9 [1.43–2.52], and 1.53 [1.2–1.95], respectively). The association between SO and CI risk was weakened but remained statistically significant after adjusting for age, sex, and educational status (OR, 1.47; 95% CI, 1.11–1.96). However, associations between sarcopenia, obesity, and CI risk disappeared after adjusting for age, sex, and educational status ($P > 0.05$). A greater risk remained even after additional adjustments for current smoking, current drinking, history of hypertension, stroke, diabetes, and dialysis vintage.

Subgroup analyses

Age, sex, educational status, dialysis vintage, history of hypertension, stroke, and diabetes are potential confounders known to influence cognitive function. To test if the association between SO and CI risk is stable in different subgroups, we did subgroup analyses and interactive analyses. As shown in Figure 2, the associations were similar across subgroups ($P > 0.05$ for interaction for all) after adjusting for the same variables as Model 4 in Table 2, except for the stratified variable.

DISCUSSION

The present study investigated the prevalence of SO and sarcopenia in Chinese MHD patients. We found that of the 2743 patients, 21.58% of the participants met the criteria for SO, 15.64% were solely sarcopenic, and 31.9%

TABLE 2 ORs for cognitive impairment according to the presence of sarcopenia and obesity.

	Model 1		Model 2		Model 3		Model 4	
Group	**OR (95%CI)**	***P***	**OR (95% CI)**	***P***	**OR (95% CI)**	***P***	**OR (95% CI)**	***P***
Nonsarcopenic and nonobesity	1.000		1.000		1.000		1.000	
Sarcopenic obesity	2.88 (2.24–3.69)	<0.001	1.47 (1.11–1.96)	0.008	1.51 (1.12–2.05)	0.008	1.54 (1.13–2.08)	0.006
Sarcopenia (nonobesity)	1.90 (1.43–2.52)	<0.001	1.26 (0.92–1.72)	0.147	1.18 (0.84–1.66)	0.327	1.20 (0.86–1.69)	0.284
Obesity (nonsarcopenic)	1.53 (1.20–1.95)	<0.001	1.13 (0.87–1.47)	0.367	1.15 (0.86–1.52)	0.343	1.15 (0.87–1.53)	0.329

Note: Model 1 is the unadjusted model. Model 2 is the model adjusted for age, sex, educational status. Model 3 is the model adjusted for the above items as well as current smoking, current drinking, and history of hypertension, stroke, and diabetes. Model 4 is the model adjusted for the above items as well as dialysis vintage.

Abbreviation: OR, odds ratio.

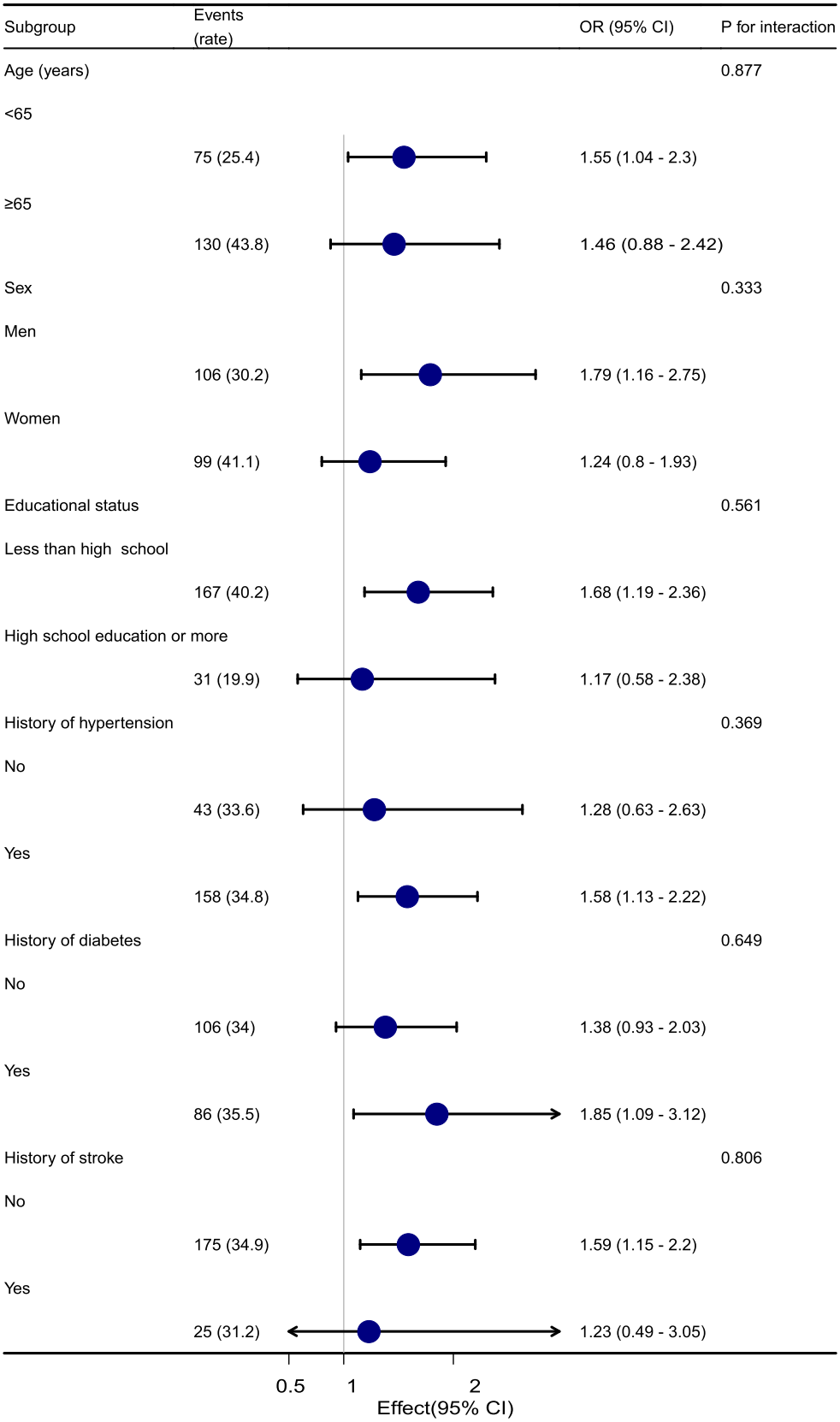

FIGURE 2 Subgroup analyses of the association between sarcopenia obesity and cognitive impairment. Odds ratios (ORs) were calculated after adjustment for current smoking, current drinking, and dialysis vintage except for the stratified variable.

were neither obese nor sarcopenic. The prevalence of CI was significantly higher in the SO group than in those with obesity or sarcopenia group. SO was associated with a heightened risk of CI compared with either obesity or sarcopenia alone. Furthermore, the association between SO and CI remained significant in different subgroups stratified by age, sex, educational status, history of hypertension, diabetes, and stroke.

Few studies have reported the prevalence of SO in MHD patients. Furthermore, previous studies were commonly single-centered and the sample sizes were relatively small.[19] The reported prevalence of SO varies from 8% to 57% depending on different definitions.[20] In the study of Aleksandra Rymarz et al,[21] sarcopenia was defined as a lean tissue index lower than the 10th percentile for age and sex. The prevalence of SO was 20.83% in their study; however, they only included 48 hemodialysis patients; 57% of participants were sarcopenic obese in a study that included 122 participants, and SO was defined according to Janssen criteria.[20] We first used the definition of sarcopenia proposed by the Asian Working Group for Sarcopenia to assess the prevalence of SO in MHD patients and found that 21.58% of the participants met the criteria for SO. SO patients were more likely to suffer from CI than those who had sarcopenia only in our study. No established uniform definition of SO exists, a uniform definition of SO in MHD patients is urgently needed to guide future research and corresponding interventions, considering the high prevalence of CI in MHD patients with SO.

It is well known that sarcopenia is associated with CI; however, the relationship between obesity and CI is contradictory in different age groups. Several studies have suggested that obesity is associated with a higher risk of CI in the middle-aged population whereas obesity is positively associated with better cognitive function in older individuals, which has been called the "obesity paradox."[22,23] "Obesity paradox" has also been established in MHD patients. Whether the potential cognitive protective effects of obesity might offset the detrimental effect of sarcopenia is unknown. Several studies have evaluated the association between SO and CI risk in the general population. However, no studies to date have investigated the relationship between SO and CI risk in end-stage renal disease patients, particularly in MHD patients, who are vulnerable to developing SO and CI. Our study provides evidence that SO is independently associated with an increased risk of CI in MHD patients. Participants in the SO group had a 1.47-fold increased risk for CI after adjusting for age, sex, and educational status. A greater risk remained even after full adjustment for relevant confounders, suggesting that these confounders only partially explain the relationship between SO and CI. This was in line with a previous study conducted on middle-aged and older participants with type 2 diabetes and a study conducted in the older Chinese community-dwelling population.[10,24] However, another study demonstrated that a positive association between SO and CI risk was only observed in adults aged ≥70 years, but not in those aged 60–69 years.[25] Thus, subgroup analysis is needed. To the best of our knowledge, no previous studies have conducted an age-stratified subgroup analysis. Furthermore, middle-aged and older participants are more likely to be complicated with hypertension, diabetes, and stroke, whether they have a potential influence on the association between SO and CI is not known. The corresponding subgroup analyses are absent. We first conducted the subgroup analyses stratified by age, sex, educational status, and medical histories and found that the positive association between SO and increased risk of CI was consistent across different subgroups.

The exact mechanisms accounting for the association between SO and increased risk of CI in MHD patients are unknown. But several plausible explanations could be speculated. First, both sarcopenia and obesity could result in decreased physical activity, and as is well known, physical inactivity is closely associated with cognitive decline.[26] In another hand, reduced physical activity could result in decreased muscle mass as well as decreased energy expenditure leading to an increased risk of sarcopenia and obesity. Thus, a vicious circle is created. This may be further confirmed by the data in our study that patients with SO had the lowest grip strength. A recent study has suggested that stronger grip strength is related to increased gray matter volume, especially in subcortical regions and temporal cortices, which correlate with better mental health.[27] Second, previous studies have demonstrated that insulin resistance plays an important role in the association between SO and cognitive functioning. Insulin resistance in obese participants is not only associated with poorer cognitive efficiency and worse brain function but also associated with accelerated muscle catabolism leading to muscle mass loss.[28] Patients with SO had the lowest lean tissue mass, and the highest level of FAT% may further support this hypothesis. Third, chronic inflammation is associated with sarcopenia, obesity, the development of SO, as well as CI. However, we did not measure inflammation markers and insulin levels. Thus, further studies are required to clarify whether SO increases CI risk via the abovementioned mechanisms.

The strengths of the present study include its multicenter study design and the subgroup analyses stratified by age, sex, educational status, and history of hypertension, diabetes, and stroke. Thus, the effect of

potential confounders was minimized. Our study contributes to providing further evidence for a stronger positive association between SO and CI risk, compared with sarcopenia or obesity alone in MHD patients. Nevertheless, this study has several limitations. First, the cross-sectional nature of our study disabled us to show any causal associations between SO and CI. Future prospective studies are needed. Second, physical activity and depression have an impact on cognitive function but we did not collect these data, these confounders and other potential confounders might have influenced the association between SO and CI in our patients. Third, FAT% was used to define obesity instead of BMI, which is less influenced by fluid overload. There is no generally accepted reference value to define SO, to date. A uniform definition of SO in MHD patients is urgently needed to guide future research and corresponding interventions. Fourth, lean tissue mass was assessed by the body composition monitor in our study, whereas lean tissue mass was assessed with DXA in many studies. The body composition monitor has been widely accepted to assess body composition in hemodialysis patients because it is not affected by overhydration.[29] Besides, we have excluded those patients with excessive fluid overload. Fifth, the Montreal Cognitive Assessment was reported to have higher predictive performance for identifying severe CI than MMSE. However, this study only included 150 US MHD patients, whether this conclusion is suitable for the Chinese is not known. Furthermore, the MMSE has become one of the most widely used cognitive screening instruments for CI and has been widely used in MHD patients.

CONCLUSION

SO and CI are highly prevalent in MHD patients. Participants with SO are at significantly higher risk of CI than those with either sarcopenia or obesity alone. Improving muscle strength, increasing muscle mass, and preventing SO may be beneficial for reducing cognitive dysfunction in MHD patients.

AUTHOR CONTRIBUTIONS

Chaomin Zhou, Lin Zhan, Jing Yuan, and Yan Zha contributed to the design, analysis, and interpretation of the data and drafted the manuscript; Yan Zha guided the writing of this paper; Jing Yuan, Lin Zhan, and PignHong He contributed to the acquisition of the data. All authors read and agreed to the final version of the manuscript.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest.

DATA AVAILABILITY STATEMENT

The data sets used and/or analyzed during the current study are available from the corresponding author upon reasonable request.

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