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Original Article

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SARC-F is a Weaker Predictor Compared to Muscle Strength and a Stronger Predictor Compared to Muscle Mass for Mortality and Hospitalization in Hemodialysis Patients

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ABSTRACT

Objective: It is known that muscle strength and muscle mass decrease in hemodialysis patients. We aimed to compare the effect of SARC-F (strength, assistance with walking, rising from a chair, climbing stairs, and falls) questionnaire with that of handgrip strength and skeletal muscle mass/body mass index on 1-year mortality and hospitalization in hemodialysis patients.

Methods: SARC-F test was filled for 67 hemodialysis patients, muscle strength was evaluated with handgrip strength, muscle mass was evaluated by performing bioimpedance analysis, and skeletal muscle mass/body mass index was evaluated by using the formula.

Results: The end of 1 year revealed that 12 of 67 patients (17.9%) died. Of the patients, 38 (56.7%) were hospitalized. The number of hospitalizations was in the range of 0-9. The length of hospitalization varied between 2 and 77 days. The patients with low handgrip strength had a 9.86 times higher mortality risk (odds ratio = 9.862, 95% CI = 1.190-81.707, *P* = .034) and had a 5.27 times higher risk of hospitalization (odds ratio = 5.273, 95% CI = 1.828-15.207, *P* = .002). The patients who had lower SARC-F had a 3.88 times higher risk of hospitalization (odds ratio = 3.882, 95% CI = 1.340-11.252, *P* = .012). A positive statistically significant correlation was found between the patients' hospitalization periods and SARC-F scores (Spearman's rho = 0.329, *P* = .007), and a negative statistically significant correlation was found between the patients' hospitalization periods and handgrip strength scores. The duration of hospitalization was found to be significantly longer in the patients who had low handgrip strength (19.38 ± 22.25).

Conclusion: SARC-F appears to be a weaker parameter than handgrip strength and a stronger parameter than skeletal muscle mass/body mass index on hospitalization and mortality.

Keywords: Hemodialysis, muscle mass, muscle strength, SARC-F, sarcopenia

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INTRODUCTION

Sarcopenia is a condition that contributes to low muscle strength and mass as well as loss of physical activity.[1] While primary sarcopenia develops mainly due to old age, secondary sarcopenia develops if there is an underlying nonaging cause such as chronic kidney disease (CKD).[2] EWGSOP2 (European Working Group Sarcopenia and Older People—the revised sarcopenia definition and diagnosis guide published in 2018) recommends the SARC-F (strength, assistance with walking, rising from a chair, climbing stairs, and falls) questionnaire scale consisting of 5 questions for sarcopenia screening. SARC-F has been found to be valid and consistent in sarcopenia screening in various patient populations.[3] A SARC-F score of 4 or higher is significant for sarcopenia. A sarcopenia diagnosis is confirmed by the presence of low muscle quantity or quality.[1,4] One of the methods used for the determination of muscle strength is handgrip strength (HGS) which was performed via dynamometer. Low HGS has been shown to be associated with functional loss, poor nutritional status, and mortality.[5,6] The determination of muscle mass is made by many methods such as bioimpedance analysis (BIA), dual-energy x-ray absorptiometry, computed tomography, and magnetic resonance imaging. With these methods, skeletal muscle mass (SMM) and appendicular muscle mass are measured by adjusting for height and body mass index (BMI).[7,8] The advantages of the BIA are ease of use, low costs, and portability.[9]

We aimed to compare the effect of SARC-F questionnaire with that of handgrip strength and skeletal muscle mass/body mass index on 1-year mortality and hospitalization in hemodialysis patients.

METHODS

Hemodialysis patients at the Selçuk University Faculty of Medicine Dialysis Unit were included in this cross-sectional study. Approval was obtained from the local ethics committee before starting the study (approval number: 2018/340). Written and verbal consents were obtained from 67 patients after exclusion of patients under 18 years of age and those who had amputation or cardiac pacemaker. The demographic data of the patients were recorded from the electronic file system.

SARC-F: The Turkish version of the SARC-F, which has been verified for reliability and validity, was used. There were 5 questions: lifting 5 kg, needing help to walk, getting up from the chair, climbing stairs, and falling incidence in the last year. Each question was scored between 0 and 2: 0 = no strain, 1 = some strain, 2 = very difficult or impossible. “Fall” 0: no fall in the last year, 1: 1-3 times fall, 2: >4 times as falls scored. The total score was 0-10. A score of <4 was considered negative for sarcopenia and ≥4 as positive for sarcopenia.[10]

Handgrip Strength: Handgrip strength test was performed with the aid of a digital dynamometer (TKK 5401 Grip D; Takei Scientific Instruments Co, Niigata, Japan). Measurements were performed on patients with arteriovenous fistula (AVF) on the non-AVF side and on the dominant arm in patients with permanent catheter before the patients underwent dialysis. Patients were seated upright in the chair. The shoulder was held in adduction and neutral position and the elbow was flexed 90°. The forearm was midrotated and supported from below. The patient was told to use maximum strength and squeeze the handle using fingers. Three measurements were taken at 30-second intervals and the highest value was recorded.[6,11] The cut-off value was 27 kg for men and 16 kg for women.[1]

MAIN POINTS

- The SARC-F scale can be used to screen for sarcopenia. Muscle strength can be calculated with handgrip strength (HGS) and muscle mass can be calculated with bioimpedance analysis-based formulas.
- Measurement of muscle strength seems to be a better predictor of muscle mass, hospitalization, and mortality in hemodialysis patients.
- The effect of SARC-F on hospitalization seems to be related to age and comorbidity.

Bioimpedance analysis: Measurements were performed using a multi-frequency bioelectric impedance analyzer (Bodystat Composition Technology, Bodystat Quadscan 4000, UK, 5-50-100-200 kHz). The procedure was started 5 minutes after the end of the dialysis session, while the patient was in the supine position. The electrodes were placed in the tetrapolar right hand and right foot. Electrodes were attached to the non-AVF side in patients with AVF. Body mass index was calculated as body weight/height^2 (kg/m^2).[2,12-14]

SMM and SMMI adjusted for BMI [kg/(kg/m^2)] were calculated using the following formulas:

SMM (kg) = SMM was calculated according to the formula created by Janssen et al.[15]

$$SMM\ (kg) = [(height/R \times 0.401) + (gender \times 3.825) + (age \times -0.071)] + 5.102$$

(Height in cm, R (resistance) in ohm, gender men = 1, women = 0, age in years)

SMM adjusted for BMI [kg/(kg/m^2)] (SMM (BMI)) = SMM (BMI) (BMI in kg/m^2) was calculated. The cut-off value was accepted as 1.049 [kg/(kg/m^2)] for men and 0.823 [kg/(kg/m^2)] for women in Turkish population.[8]

Modified Charlson Comorbidity Index: Modified Charlson Comorbidity Index is a comorbidity scale that predicts mortality in the general population and hemodialysis patients.[16] Modified Charlson Comorbidity Index was calculated in all patients. Since they were hemodialysis patients, the lowest possible score was 2. Patients were scanned for coronary artery disease, congestive heart failure, peripheral vascular disease, cerebrovascular accident, dementia, chronic obstructive pulmonary disease, gastric ulcer, chronic liver disease, diabetes mellitus (DM), and cancer (including hematological malignancies). An additional point was added to the score for every decade over 40 years of age.[17,18]

Laboratory Examination

Before starting the hemodialysis session, blood samples were taken from the patients for urea, creatinine, albumin, calcium, phosphorus, iron, ferritin, lipid profile, C-reactive protein, and hemogram. At the end of the same session, blood samples were taken for the urea level to calculate Kt/V. https://qxmd.com/calculate/calculator_128/kt-v-daugirdas website was used to evaluate the Kt/V values.

Statistical Analysis

All statistical analysis was performed using R 3.6.0 (The R Foundation for Statistical Computing, Vienna, Austria). The Shapiro–Wilk's normality test and Q–Q plots were used to assess the normality of the data, and also Levene's test was used to check the homogeneity of the variances. Numerical variables were presented as mean ± standard deviation (range: minimum–maximum) or median with interquartile range (25th percentile-75th percentile). Categorical variables were described as count (n) and percentage (%). Univariate logistic regression analysis was used to determine the risk factors of parameters on mortality and hospitalization. And also, multiple logistic regression analysis was performed with adjusted age and MCCI. We conducted to identify the independent risk factors of the length of stay in hospital using univariate and multiple Poisson regression analysis. A *P* value less than .05 was considered statistically significant.

RESULTS

Of the 67 patients included in the study, 47.8% were female (n = 32), 35% were male (n = 32), and the mean age of the patients was 55.48 ± 16.53 (18-83). Diabetes mellitus was present in 32.8% of the patients. The mean MCCI value was 5.75 ± 2.58 and the median value for dialysis time was 24 months. Obesity was present in 23.9% of the patients and the general mean BMI value was 25.74 ± 5.70 kg/m^2. The mean HGS was 20 ± 7.16, and 59.7% of the patients had a low HGS. The mean SMM (BMI) was 1.06 ± 0.23 and 31.3% had a low BMI. The mean SARC-F score was 3.31 ± 2.59, and 41.8% of the patients had a SARC-F score of 4 and above (Table 1).

We included age, gender, DM, vascular access, MCCI, dialysis time, Kt/V, hemoglobin, albumin, BMI, HGS, SMMI, and SARC-F score in the univariate logistic regression analysis to determine the predictors of mortality and hospitalization (Table 2). Handgrip strength, SMMI, and SARC-F scores were included in the analysis, both numerically and categorized. It was determined that MCCI and HGS were effective risk factors for mortality. It was found that the increase in MCCI score increased the mortality rate by approximately 1.4 times (odds ratio (OR) = 1.379, 95% CI = 1.053-1.805, *P* =.019). The patients with low HGS had a 9.86 times higher mortality risk compared to the patients with normal HGS (OR =9.862, 95% CI = 1.190-81.707, *P* = .034). However, when correction was made according to the MCCI value in the multiple logistic regression analysis, the effect of HGS on mortality was not statistically significant (adjusted OR = 6.481, 95% CI = 0.735-57.105, *P* =.092). SARC-F and SMM (BMI) were not risk factors for mortality (*P* = .992 and *P* = .370, respectively). As the age of the patients increased, the risk of hospitalization increased by approximately 7% (OR = 1.072, 95% CI = 1.030-1.115, *P* =.001). With the increase in the MCCI score, the risk of hospitalization of patients increased by 1.3 times (OR = 1.302, 95% CI = 1.047-1.620, *P* =.018). The patients with low HGS had a 5.27 times higher risk of hospitalization compared to the patients with normal HGS (OR = 5.273, 95% CI = 1.828-15.207,

Table 1. The Demographics and Laboratory Characteristics and Malnutrition and Sarcopenia Findings of the Patients

Characteristics	Patients (*n* = 67)
Laboratory and demographic characteristics	
Age (years), mean ± SD (min-max)	55.48 ± 16.53 (18-83)
Aging, *n* (%)	
≤65 years	41 (61.2)
>65 years	26 (38.8)
Gender, n (%)	
Female	32 (47.8)
Male	35 (52.2)
Diabetes mellitus, n (%)	
No	45 (67.2)
Yes	22 (32.8)
Vascular access, n (%)	
Permanent catheter	34 (50.7)
AVF	33 (49.3)
MCCI, mean ± SD (min-max)	5.75 ± 2.58 (2-13)
Dialysis time (months), median (IQR)	24 (9-42)
Kt/V, mean ± SD (min-max)	1.61 ± 0.32 (0.90-2.63)
Hemoglobin (g/dL), mean ± SD (min-max)	11.26 ± 1.22 (7.90-14)
Albumin (g/dL), median (IQR)	3.90 (3.60-4.10)
Calcium (mg/dL), median (IQR)	8.90 (8.50-9.30)
Phosphorus (mg/dL), mean ± SD (min-max)	4.94 ± 1.46 (2.60-9.50)
Ferritin (µg/L), median (IQR)	578 (351-753)
Total cholesterol (mg/dL), median (IQR)	171 (152-206)
Triglyceride (mg/dL), median (IQR)	160 (130-272)
Malnutrition and sarcopenia findings	
BMI (kg/m^2), mean ± SD (min-max)	25.74 ± 5.70 (16.80-44)
Obesity, n (%)	
BMI < 30 kg/m^2	51 (76.1)
BMI ≥ 30 kg/m^2	16 (23.9)
HGS (kg), mean ± SD (min-max)	20 ± 7.16 (5.60-38.20)
HGS level, *n* (%)	
Normal muscle strength	27 (40.3)
Low muscle strength	40 (59.7)
SMMI (BMI) [kg/(kg/m^2)], mean ± SD (min-max)	1.06 ± 0.23 (0.34-1.48)
SMMI (BMI) level, *n* (%)	
Low	21 (31.3)
Normal	46 (68.7)
SARC-F score, mean ± SD (min-max)	3.31 ± 2.59 (0-9)
SARC-F level, *n* (%)	
Sarcopenia (SARC-F score ≥ 4)	28 (41.8)
Non-Sarcopenia (SARC-F score < 4)	39 (58.2)

Values are expressed as mean ± standard deviation (range: minimum-maximum), median (interquartile range) or counts (n) and percentages (%).
MCCI, modified Charlson comorbidity index; SMMI, skeletal muscle mass index; BMI, body mass index; HGS, hand grip strength; SD, standard deviation; IQR, interquartile range (25th percentile-75th percentile); SARC-F, strength, assistance with walking, rising from a chair, climbing stairs, and falls; HGS, handgrip strength; SMMI (BMI), skeletal muscle mass/body mass index.

Table 2. Evaluation of Risk Factors for Mortality and Hospitalization in Hemodialysis Patients by Univariate Logistic Regression Analysis

	Mortality		Hospitalization	
	Crude OR (95% CI)	*P*	Crude OR (95% CI)	*P*
Numerical variables				
Age (years)	1.04 (0.99-1.09)	.108	1.07 (1.03-1.12)	**.001**
MCCI	1.38 (1.05-1.81)	**.019**	1.30 (1.05-1.62)	**.018**
Dialysis time (months)	0.99 (0.98-1.02)	.903	0.99 (0.98-1.01)	.441
Kt/V	0.17 (0.02-1.54)	.115	0.23 (0.04-1.18)	.078
Hemoglobin (g/dL)	0.87 (0.52-1.45)	.591	1.04 (0.70-1.55)	.836
Albumin (g/dL)	0.25 (0.04-1.63)	.147	1.03 (0.68-1.57)	.885
BMI (kg/m^2)	1.03 (0.92-1.14)	.608	1.06 (0.97-1.16)	.230
HGS (kg)	0.90 (0.81-0.99)	**.040**	0.85 (0.78-0.94)	**.001**
SMMI (BMI) [kg/(kg/m^2)]	3.83 (0.20-72.40)	.370	0.39 (0.05-3.47)	.402
SARC-F Score	1.15 (0.90-1.46)	.258	1.39 (1.11-1.74)	**.005**
Categorical variables				
Gender				
Female	[Reference]		[Reference]	
Male	2.07 (0.56-7.70)	.276	1.04 (0.39-2.73)	.941
Diabetes mellitus				
No	[Reference]		[Reference]	
Yes	3.73 (1.03-13.59)	**.046**	1.53 (0.54-4.37)	.425
HGS level				
Normal muscle strength	[Reference]		[Reference]	
Low muscle strength	9.86 (1.19-81.71)	**.034**	5.27 (1.83-15.21)	**.002**
SMMI (BMI) level				
Normal	[Reference]		[Reference]	
Low	2.64 (0.52-13.29)	.239	2.50 (0.83-7.58)	.105
SARC-F level				
Non-Sarcopenia (SARC-F score <4)	[Reference]		[Reference]	
Sarcopenia (SARC-F score ≥4)	0.99 (0.28-3.53)	.992	3.88 (1.34-11.25)	**.012**

Bold values denote statistical significance at the $P < .05$ level.
MCCI, modified Charlson comorbidity index; SMMI, skeletal muscle mass index; BMI, body mass index; HGS, hand grip strength; OR, odds ratio; SARC-F, strength, assistance with walking, rising from a chair, climbing stairs, and falls; HGS, handgrip strength; SMMI (BMI), skeletal muscle mass/body mass index; OR, odds ratio.

P = .002). When corrected for age and MCCI value in the multiple logistic regression analysis, the effect of those with low HGS was 3.88 times higher compared to those with high HGS (adjusted OR = 3.881, 95% CI = 1.222-12.330, *P* = .021). The patients with a SARC-F value of ≥4 had a 3.88 times higher risk of hospitalization compared to those with a SARC-F value of <4 (OR = 3.882, 95% CI = 1.340-11.252, *P* =.012). However, the effect of SARC-F on hospitalization was not statistically significant when adjusted for age and MCCI (adjusted OR = 2.307, 95% CI = 0.691-7.700, *P* = .174).

We included age, gender, DM, vascular access, MCCI, dialysis time, Kt/V, hemoglobin, albumin, BMI, HGS, SMMI, and SARC-F score in the univariate and multiple Poisson regression analysis to determine the predictors of length of stay in hospital also (Table 3). Handgrip strength, SMMI, and SARC-F scores were included in the analysis, both numerically and categorized. In model 1, both univariate and multiple analysis, while the increase in age, MCCI, hemoglobin, albumin, SMMI, and SARC-F values increased the length of stay in hospital, the increase in dialysis time Kt/V and HGS values decreased this length. Although, there was no significant effect of BMI on length of stay in hospital (*P* =.378) in the univariate analysis, the effect of BMI was significant in the multiple analysis. In model 2, both univariate and multiple analyses, male compared to female, permanent catheter compared to AVF, low muscle strength compared to normal, low SMMI compared to normal, and sarcopenia compared to non-sarcopenia were expected to have a rate greater for the length of stay in hospital. Moreover, patients with DM had a longer length of stay in hospital compared to patients without DM in the univariate analysis, but the effect of DM was not significantly in the multiple analysis.

DISCUSSION

In this study, we found that low HGS increased the risk of hospitalization and increased mortality depending on comorbidities after a 1-year follow-up period in hemodialysis patients. On the other hand, we found that low HGS and a SARC-F value of 4 and above were correlated with increased length of hospital stay. However, we could not find any effect of BMI and SMM (BMI) on mortality, hospitalization, and length of stay.

The revised EWSGOP2 criteria for sarcopenia screening recommend SARC-F, which is a simple, inexpensive, and easily applicable test.[1] SARC-F in hemodialysis patients in the literature by Yamamoto et al[22] examined the relationship between the physical limitation and SARC-F. They found that patients with SARC-F≥4 had lower handgrip and leg strength, shorter one-leg standing time, slower gait speed, and significantly lower short physical performance battery. However, they did not determine the body composition required for the measurement of muscle mass, a component of the sarcopenia diagnosis, and stated that this was the limitation of their study.[22] Although the correlation between the SARC-F scale and morbidity and mortality has not been studied in hemodialysis patients, there are a few studies conducted on other patient groups. In a comprehensive study conducted by Yang et al[23] on elderly patients living in a nursing home, whether SARC-F and SARC-CalF predicted mortality after 1 year was comparatively investigated, and it was found

Table 3. Evaluation of Risk Factors for Length of Stay in Hospital in Hemodialysis Patients by Univariate and Multiple Poisson Regression Analysis

	Univariate		Multiple	
	IRR (95% CI)	*P*	IRR (95% CI)	*P*
Model 1 – Numerical variables				
Age (years)	1.03 (1.02-1.03)	<.001	1.02 (1.01-1.03)	<.001
MCCI	1.10 (1.07-1.12)	<.001	0.94 (0.90-0.97)	<.001
Dialysis time (months)	0.99 (0.98-0.99)	<.001	0.98 (0.98-0.99)	**.001**
Kt/V	0.56 (0.45-0.68)	<.001	0.58 (0.44-0.77)	<.001
Hemoglobin (g/dL)	1.10 (1.04-1.16)	<.001	1.12 (1.06-1.18)	<.001
Albumin (g/dL)	1.07 (1.03-1.11)	<.001	1.17 (1.11-1.23)	<.001
BMI (kg/m^2)	0.99 (0.98-1.01)	.378	0.96 (0.94-0.98)	<.001
HGS (kg)	0.95 (0.94-0.96)	<.001	0.93 (0.92-0.94)	<.001
SMMI (BMI) [kg/(kg/m^2)]	1.56 (1.18-2.07)	**.002**	3.79 (2.33-6.25)	<.001
SARC-F Score	1.14 (1.11-1.16)	<.001	1.12 (1.09-1.16)	<.001
Model 2 – Categorical variables				
Gender				
Female (*n* = 32)	[Reference]		[Reference]	
Male (*n* = 35)	1.61 (1.41-1.84)	<.001	1.27 (1.10-1.46)	**.001**
Diabetes mellitus				
No (*n* = 44)	[Reference]			
Yes (*n* = 22)	1.21 (1.06-1.38)	**.004**	–	
Vascular access				
Permanent catheter (*n* = 34)	[Reference]		[Reference]	
AVF (*n* = 33)	0.39 (0.34-0.45)	<.001	0.50 (0.43-0.58)	<.001
HGS level				
Normal muscle strength (*n* = 27)	[Reference]		[Reference]	
Low muscle strength (*n* = 40)	2.62 (2.24-3.06)	<.001	1.77 (1.47-2.13)	<.001
SMMI (BMI) level				
Low (*n* = 46)	[Reference]		[Reference]	
Normal (*n* = 21)	0.94 (0.82-1.08)	.385	0.72 (0.62-0.83)	<.001
SARC-F level				
Non-Sarcopenia (SARC-F score < 4) (*n* = 28)	[Reference]		[Reference]	
Sarcopenia (SARC-F score ≥ 4) (*n* = 39)	1.49 (1.31-1.69)	<.001	1.42 (1.24-1.64)	<.001

Bold values denote statistical significance at the $P < .05$ level.
MCCI, modified Charlson comorbidity index; SMMI, skeletal muscle mass index; BMI, body mass index; HGS, hand grip strength; IRR, incidence rate ratio SARC-F, strength, assistance with walking, rising from a chair, climbing stairs, and falls; HGS, handgrip strength; SMMI (BMI), skeletal muscle mass/body mass index.

that SARC-F was a better predictor. In China, the SARC-F and Ishii scores were compared for 1-year re-hospitalization, and SARC-F was found to be a better predictor for re-hospitalization.[24] Again, SARC-F was found to be a significant predictor for 2-year mortality in a study conducted on elderly patients.[25] We found that SARC-F did not significantly predict mortality in hemodialysis patients. At 1 year follow-up, hospitalization was significantly higher in those with a SARC-F value of ≥ 4, but this effect was associated with age and comorbidity. The length of stay increased as the SARC-F score increased. In our study, the fact that SARC-F had no effect on mortality might be associated with several reasons. Different patient population, a 1-year follow-up period, and low number of patients in our study might have affected the results.

In this study, we evaluated muscle strength with HGS. There are many studies showing that HGS predicts hospitalization and mortality in dialysis patients.[19-21] In our study, the mortality risk of the patients with low HGS was 9.86 times higher compared to the ones who had normal HGS. However, when adjustment was made for the comorbidity factor, this effect disappeared. But even when adjustment for risk of hospitalization, age, and MCC value was made, the effect of those with low HGS was 3.88 times higher compared to those with high HGS. Again, there was a negative correlation between hospitalization time and HGS.

We evaluated muscle strength with muscle mass with SMM (BMI). We used the values set by Bahat et al[10] for patients as the cut-off value. Kittiskulnam et al have shown that the use of SMM (height^2) in hemodialysis patients shows lower muscle mass prevalence. Therefore, the use of SMM (BMI) may be more appropriate.[2,26] In our study, we could not find a correlation between SMM (BMI) and hospitalization and mortality. In fact, some studies conducted in the last 10 years were consistent with our results. In a long-term follow-up study conducted by Isoyama et al.[27] muscle strength rather than muscle mass was associated with mortality in hemodialysis patients. Similarly, Kittiskulnam et al[28] did not find a correlation between muscle mass and mortality. Lin et al[19] showed that muscle strength was a better predictor for hospitalization and mortality compared to muscle mass.[19]

Unlike the above-mentioned studies, we comparatively investigated whether SARC-F was a good predictor for hospitalization and mortality in hemodialysis patients, in addition to other criteria of sarcopenia. At the end of the study, we observed that SARC-F did not predict mortality and its effect on hospitalization depended on age and comorbidities. However, there was a positive correlation between SARC-F and length of stay. Although the effect of HGS on mortality depended on comorbidities, its effect on hospitalization and length of stay was more significant. However, muscle mass had no effect on hospitalization or mortality.

This study has some limitations. The number of patients included in our study was low, it was a single-centered study and our follow-up period was 1 year. However, it is the first study to investigate the predictive effect of SARC-F in terms of hospitalization and mortality in hemodialysis patients.

CONCLUSION

In conclusion, we found that muscle strength was the best predictor among the sarcopenia parameters, while SARC-F, an easy and simple test, was an acceptable test in predicting hospitalization. However, we think that these results should be supported by larger and long-term studies.

Ethics Committee Approval: Ethical committee approval was received from the Ethics Committee of Selçuk University (Date: June 3, 2020, Decision No: 2020/232).

Informed Consent: Written informed consent was obtained from all participants who participated in this study.

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Author Contributions: Concept – Y.C.Y.; Design –Y.C.Y.; Z.B., L.A.; Materials – S.Y., E.B., M.C.K.; Data Collection and/or Processing – N.A., Analysis and/or Interpretation – S.A., D.E.; Literature Review – Y.C.Y., M.C.A., S.Y., L.A., Z.B.; Writing – Y.C.Y.; Critical Review – Y.C.Y.

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REFERENCES

1. Cruz-Jentoft AJ, Bahat G, Bauer J, et al. Sarcopenia: revised European consensus on definition and diagnosis. *Age Ageing*. 2019; 48(4):601. [CrossRef]
2. Kittiskulnam P, Carrero JJ, Chertow GM, Kaysen GA, Delgado C, Johansen KL. Sarcopenia among patients receiving hemodialysis: weighing the evidence. *J Cachexia Sarcopenia Muscle*. 2017;8(1):57-68. [CrossRef]
3. Voelker SN, Michalopoulos N, Maier AB, Reijnierse EM. Reliability and concurrent validity of the SARC-F and its modified versions: a systematic review and meta-analysis. *J Am Med Dir Assoc*. 2021;22(9):1864-1876.e16. [CrossRef]
4. Beaudart C, McCloskey E, Bruyère O, et al. Sarcopenia in daily practice: assessment and management. *BMC Geriatr*. 2016;16(1): 170. [CrossRef]
5. Leong DP, Teo KK, Rangarajan S, et al. Prognostic value of grip strength: findings from the Prospective Urban Rural Epidemiology (PURE) study. *Lancet*. 2015;386(9990):266-273. [CrossRef]
6. Yu R, Ong S, Cheung O, Leung J, Woo J. Reference values of grip strength, prevalence of low grip strength, and factors affecting grip strength values in Chinese adults. *J Am Med Dir Assoc*. 2017; 18(6):551.e9-e16.
7. Cruz-Jentoft AJ, Bahat G, Bauer J, et al. Sarcopenia: revised European consensus on definition and diagnosis. *Age Ageing*. 2019;48(1):16-31. [CrossRef]
8. Bahat G, Tufan A, Kilic C, et al. Cut-off points for height, weight and body mass index adjusted bioimpedance analysis measurements of muscle mass with use of different threshold definitions. *Aging Male*. 2018:1-6.
9. Soares JDP, Gomes TLN, Siqueira JM, et al. Muscle function loss is associated with anxiety in patients with gastrointestinal cancer. *Clin Nutr ESPEN*. 2019;29:149-153. [CrossRef]
10. Bahat G, Yilmaz O, Kılıç C, Oren MM, Karan MA. Performance of SARC-F in regard to sarcopenia definitions, muscle mass and functional measures. *J Nutr Health Aging*. 2018;22(8):898-903. [CrossRef]
11. Hernández-Martínez J, Cisterna D, Ramírez-Campillo R, et al. Association of maximal voluntary isometric handgrip strength with age, gender and handedness in older people. *Rev Med Chil*. 2018;146(12):1429-1437. [CrossRef]
12. Bayram E, Topcu Y, Karakaya P, et al. Correlation between motor performance scales, body composition, and anthropometry in

patients with Duchenne muscular dystrophy. *Acta Neurol Belg*. 2013;113(2):133-137. [CrossRef]
13. Ozturk S, Taymez DG, Bahat G, et al. The influence of low dialysate sodium and glucose concentration on volume distributions in body compartments after haemodialysis: a bioimpedance analysis study. *Nephrol Dial Transplant*. 2008;23(11):3629-3634. [CrossRef]
14. Rymarz A, Matyjek A, Gomółka M, Niemczyk S. Lean tissue index and body cell mass can be predictors of low free testosterone levels in men on hemodialysis. *J Ren Nutr*. 2019;29(6):529-535. [CrossRef]
15. Janssen I, Heymsfield SB, Baumgartner RN, Ross R. Estimation of skeletal muscle mass by bioelectrical impedance analysis. *J Appl Physiol (1985)*. 2000;89(2):465-471. [CrossRef]
16. Fried L, Bernardini J, Piraino B. Comparison of the Charlson comorbidity index and the Davies score as a predictor of outcomes in PD patients. *Perit Dial Int*. 2003;23(6):568-573. [CrossRef]
17. Kjærgaard M, Joakimsen R, Jorde R. Low serum 25-hydroxyvitamin D levels are associated with depression in an adult Norwegian population. *Psychiatry Res*. 2011;190(2-3):221-225. [CrossRef]
18. Vellekkatt F, Menon V. Efficacy of vitamin D supplementation in major depression: a meta-analysis of randomized controlled trials. *J Postgrad Med*. 2019;65(2):74-80. [CrossRef]
19. Lin YL, Liou HH, Wang CH, et al. Impact of sarcopenia and its diagnostic criteria on hospitalization and mortality in chronic hemodialysis patients: a 3-year longitudinal study. *J Formos Med Assoc*. 2020;119(7):1219-1229. [CrossRef]
20. Matos CM, Silva LF, Santana LD, et al. Handgrip strength at baseline and mortality risk in a cohort of women and men on hemodialysis: a 4-year study. *J Ren Nutr*. 2014;24(3):157-162. [CrossRef]
21. Vogt BP, Borges MCC, Goés CR, Caramori JCT. Handgrip strength is an independent predictor of all-cause mortality in maintenance dialysis patients. *Clin Nutr*. 2016;35(6):1429-1433. [CrossRef]
22. Yamamoto S, Matsuzawa R, Harada M, et al. SARC-F questionnaire: rapid and easy tool for identifying physical limitations in hemodialysis patients. *JCSM Clin Rep*. 2019;4(1):1-12. [CrossRef]
23. Yang M, Jiang J, Zeng Y, Tang H. Sarcopenia for predicting mortality among elderly nursing home residents: SARC-F versus SARC-CalF. *Med (Baltim)*. 2019;98(7):e14546. [CrossRef]
24. Li M, Kong Y, Chen H, Chu A, Song G, Cui Y. Accuracy and prognostic ability of the SARC-F questionnaire and Ishii's score in the screening of sarcopenia in geriatric inpatients. *Braz J Med Biol Res*. 2019;52(9):e8204. [CrossRef]
25. Cao L, Chen S, Zou C, et al. A pilot study of the SARC-F scale on screening sarcopenia and physical disability in the Chinese older people. *J Nutr Health Aging*. 2014;18(3):277-283. [CrossRef]
26. Bahat G, Kilic C, Ilhan B, Karan MA, Cruz-Jentoft A. Association of different bioimpedanciometry estimations of muscle mass with functional measures. *Geriatr Gerontol Int*. 2019;19(7):593-597. [CrossRef]
27. Isoyama N, Qureshi AR, Avesani CM, et al. Comparative associations of muscle mass and muscle strength with mortality in dialysis patients. *Clin J Am Soc Nephrol*. 2014;9(10):1720-1728. [CrossRef]
28. Kittiskulnam P, Chertow GM, Carrero JJ, Delgado C, Kaysen GA, Johansen KL. Sarcopenia and its individual criteria are associated, in part, with mortality among patients on hemodialysis. *Kidney Int*. 2017;92(1):238-247. [CrossRef]