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RESEARCH PAPER

Probable sarcopenia: associations with common geriatric syndromes and comorbidities in Turkish geriatric patients from a university hospital

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Key summary points

Aim To identify the associations between probable sarcopenia and common geriatric syndromes in a sample of community-dwelling older adults.

Findings The prevalence of probable sarcopenia was 12.7%; frailty, male sex and chronic kidney disease were identified as independent associations of sarcopenia.

Message Frailty screening should be carried out and comorbidity status should be identified in the presence of probable sarcopenia without waiting for loss of muscle mass to ensure the early application of appropriate measures.

Abstract

Purpose EWGSOP2 defines "probable sarcopenia" as the presence of low muscle strength without non-muscle causes. The associations of probable sarcopenia have been studied in few reports to date, and our intention in this study is to identify associations of probable sarcopenia with common geriatric syndromes in a sample of older adults who attended the geriatric outpatient clinic of Istanbul University Hospital.

Methods The present study was designed as a retrospective cross-sectional study. We performed a comprehensive geriatric assessment to the participants. Univariate analyses were performed to determine relationship of probable sarcopenia with age, sex, common geriatric syndromes, i.e., frailty, falls, polypharmacy, malnutrition, and comorbidities, i.e., diabetes mellitus, hypertension, chronic kidney disease, chronic obstructive pulmonary disease (COPD), congestive heart failure (CHF), depression, osteoporosis, and the variables found to be significant were included in logistic regression analyses. The results are presented as an odds ratio (OR), with a 95% confidence interval (CI).

Results Included in the study were 456 participants with a mean age of 74.6 ± 6.6 years, of which 71.1% were female. Probable sarcopenia was identified in 12.7% ($n = 58$) of the sample. A multivariate analysis was carried out, the factors associated with probable sarcopenia were identified as male sex (OR 0.269, 95% CI 0.142–0.510), frailty (OR 4.265, 95% CI 2.200–8.267) and chronic kidney disease (OR 3.084, 95% CI 1.105–8.608).

Conclusion Probable sarcopenia was more significantly associated with frailty than with other geriatric syndromes, signifying its importance as a marker for frailty. The study further identified chronic renal failure as a factor significantly associated with probable sarcopenia among the variety of studied diseases that frequently accompany aging.

Keywords Probable sarcopenia · Sarcopenia · Frailty · Comorbidity

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Introduction

Sarcopenia is a common geriatric syndrome that is associated with adverse health outcomes. Studies into the prevention and treatment of sarcopenia are developing quickly, but many questions remain unanswered. The core symptom of the sarcopenia condition is the quantitative and qualitative loss of skeletal muscle [1]. Several definitions of sarcopenia have been proposed to date. The European Working Group on Sarcopenia in Older People (EWGSOP) developed a practical clinical definition and consensus diagnostic criteria for age-related sarcopenia [2]. Accordingly, the prevalence of sarcopenia varies depending on the definition, setting and age group [3–5]. A systematic review reported the prevalence of sarcopenia to range between 9.9 and 40.4%, depending on the definition used [6].

In October 2018, the EWGSOP2 was published, updating the original definition of sarcopenia [7]. EWGSOP2 identifies low muscle strength as the primary parameter in the diagnosis of sarcopenia, muscle strength being at present the most reliable measure of muscle function. Specifically, when low muscle strength is detected without non-muscular causes, sarcopenia is probable. A diagnosis of probable sarcopenia is enough to trigger an assessment of the cause and to start intervention. Low muscle strength on its own, however, is considered sufficient for the initiation of interventions [7], as the adverse effects of untreated muscle weakness can be immense for the person, even without low muscle mass and quality, and in terms of healthcare costs [8].

Adverse outcomes such as mortality, falls and hip fractures have been shown to be correlated with sarcopenia, as well as with its individual components [9–11]. As such, the early diagnosis of sarcopenia is important for the prevention of possible adverse consequences. The prevalence of sarcopenia (low muscle mass + low muscle strength) and its associations with geriatric syndromes and chronic conditions have been investigated in detail [12].

Muscle strength begins to decrease before muscle mass with aging, and so probable sarcopenia cases cover a larger group than confirmed sarcopenia cases in which there is decreased muscle mass in addition to decreased muscle strength. With this in mind, low muscle strength (probable sarcopenia) is a parameter that needs to be processed separately. The literature contains a number of studies examining the relationship between handgrip strength (HGS) as a continuous variable and chronic conditions [13, 14], in which higher odds of multimorbidity and malnutrition have been reported to be associated with low HGS [13, 14]. To date, however, there have been few studies investigating the associations of probable sarcopenia, which is considered as presence of low HGS below a certain cutoff threshold. One such study investigated the association between probable sarcopenia and multimorbidity [15], and the authors reported that patients with multimorbidity were almost twice as likely to have probable sarcopenia than those without [15]. Another study investigating the relationship between probable sarcopenia and undernutrition also identified a positive association as well [16]. Some other studies have investigated the relationship between chronic kidney disease and diabetes mellitus with probable sarcopenia [15, 17, 18], although to the best of our knowledge, there has been no study to date examining the association of probable sarcopenia with other common geriatric syndromes (i.e., frailty, falls, and depression) and other common chronic diseases. Consequently, the present study investigates the common geriatric syndromes and comorbidities associated with probable sarcopenia.

Methods

Included in this retrospective cross-sectional study were community-dwelling outpatients who presented to the outpatient geriatrics clinic of a university hospital between November 2016 and March 2019. Upon the presentation of a patient to the clinic, we perform a comprehensive geriatric assessment (CGA), including an assessment for components of sarcopenia if the general condition of the participant and staff availability allow. Older adults can apply to the clinic if they are ≥ 60 years of age, with no additional requirements. They may be directed from other disciplines or may apply by themselves. Excluded from the study were those who scored less than 21 points in the Mini-Mental State Examination (MMSE), and those with moderate or severe dementia, and severe visual or hearing loss. All of the participants provided informed consent for their inclusion in the study, which was approved by the Ethics Committee of the Istanbul University, Istanbul Faculty of Medicine with decision number 1707. We collected demographic and clinical data including age, sex, height (cm), weight (kg) and living status (alone or cohabiting), as well as the name and number of chronic diseases. The participants and/or their relatives were asked whether the patient had suffered a fall in the previous 1 year, and e a single fall was considered positive. Functional capacity was assessed with the Katz Index of Independence in Activities of Daily Living (Katz ADL) and the Lawton Instrumental Activities of Daily Living Scale (IADL) measurements. The participants were asked if they did the indexing activity without help (1 point), with some help or if they were completely dependent (0 point). With respect to the ADL scores, 0 point represented total dependency and 6 points represented total independency. Regarding the IADL scores, 0 point represented total dependency and 8 points represented total independency [19, 20]. A Mini Nutritional Assessment short form (MNA-SF) for the

assessment of nutritional status indicates the presence of either malnutrition, malnutrition risk or normal nutritional status when the score is 0–7 points, 8–11 points, and > 11 points, respectively [21, 22]. For the assessment of the number of medications, polypharmacy was defined as the daily use of five or more medications [23]. Frailty was assessed with the FRAIL scale, which assesses five components: fatigue, resistance, ambulation, illness and loss of weight. The Frail scale is scored in a range of 0–5, in which ≥ 3 indicates frail; 1–2 pre-frail; and 0 indicates robust health status [24]. In our study, FRAIL scores ≥ 3 are considered frail and scores < 3 non-frail.

A Jamar hydraulic hand dynamometer was used by the same physical therapist following a well-validated protocol for the HGS evaluation [25, 26]. The patient was seated in an armless chair in an upright position with the elbow flexed at 90°, and was instructed to apply maximum pressure to the device for three seconds. Three measurements were taken from each hand and the HGS value was accepted as the maximum grip strength. Participants with problems that could influence HGS measurement, e.g., cognitive impairment, hand osteoarthritis, stroke of depression, peripheral artery disease, and neuropathy were excluded from the study. The EWGSOP2 cutoff points for probable sarcopenia were accepted as HGS < 27 kg in males and < 16 kg in females [7].

Specific comorbidities were ascertained from the patients' folders and the physician's notes. If a patient had taken medication for the comorbidity, the item was marked yes. For example, prevalent diabetes mellitus was defined as self-report of physician diagnosis (from the folder of the participant) or antidiabetic medication use (oral antidiabetic agents and insulin). We included the participants with chronic kidney disease whose eGFR is < 60 ml/min/1.73 m^2. Hemodialysis patients were excluded from the study. For COPD, the patients were classified by the percentage of predicted FEV_1 (forced expiratory volume), and we included the patients whose FEV_1 varies between 50 and 70% (mild, moderate).

Statistical analyses

All variables were assessed in terms of the normality of their distribution, ascertained through a Kolmogorov–Smirnov test. Numerical variables with a normal distribution were presented as mean ± standard deviation, and those with skewed distribution were presented as median values (minimum–maximum). Categorical variables were presented as frequencies. Comparisons of the two groups were made with an independent sample *t* test or a Mann–Whitney *U* test where appropriate. A Chi-square test and a Fisher's exact test were used for the comparison of non-numerical data. *P* values less than 0.05 were accepted as statistically significant. Binary logistic regression models were used to investigate the associations between variables. Logistic regression analyses were carried out to identify the relationship between the presence of probable sarcopenia (independent variable) and geriatric syndromes and comorbidities (dependent variable). We established three models, and included the variables in the models that were significant in a univariate analysis so as not to underestimate the significant associations. Model 1 was adjusted for age and sex, and geriatric syndromes such as malnutrition were added to age and sex for Model 2. Finally, all variables that were significant in a univariate analysis were added to create Model 3. The associations were expressed as odds ratios (OR) with a 95% confidence interval (CI), and the fitness of each model was evaluated using a Hosmer–Lemeshow goodness-fit test. *P* values were based on two-sided tests and were considered statistically significant at $p < 0.05$. IBM SPSS Statistics for Windows (Version 22.0. Armonk, NY: IBM Corp.) was used for the statistical analysis.

Results

In the defined study period, 1031 patients attended the outpatient clinic, of which 108 declined to give informed consent for their participation, 91 had cognitive impairment, 216 were unable to undergo the handgrip strength measurement procedure due to a present condition and 160 patients had missing data. The study sample thus comprised a total of 456 participants who met the inclusion criteria and were consequently included in the study (Fig. 1). The mean age of the final sample was 74.6 ± 6.6 years, and 324 (71.1%) were female. The mean BMIs were 28.2 ± 4.4 kg/m^2 and 31.2 ± 6 kg/m^2 for males and females, respectively. The characteristics of the study population, including age, comorbidities, anthropometric data, number of drugs, falls, functionality, nutritional status and frailty are reproduced in (Table 1).

Probable sarcopenia was identified in 58 (12.7%) of the participants, and the male participants were more likely to have probable sarcopenia (19.7% vs. 9.8% in males and females, respectively; $p = 0.008$).

Univariate analyses for the association of study variables and probable sarcopenia

Univariate analyses to identify the association of probable sarcopenia with sex, age, comorbidities such as diabetes mellitus, hypertension, chronic kidney disease, chronic obstructive pulmonary disease, congestive heart failure, depression and osteoporosis, which are common in older adults, and common geriatric syndromes like frailty, falls, polypharmacy and malnutrition. A comparison of patients without probable sarcopenia and those with probable sarcopenia revealed a higher number of chronic diseases in the

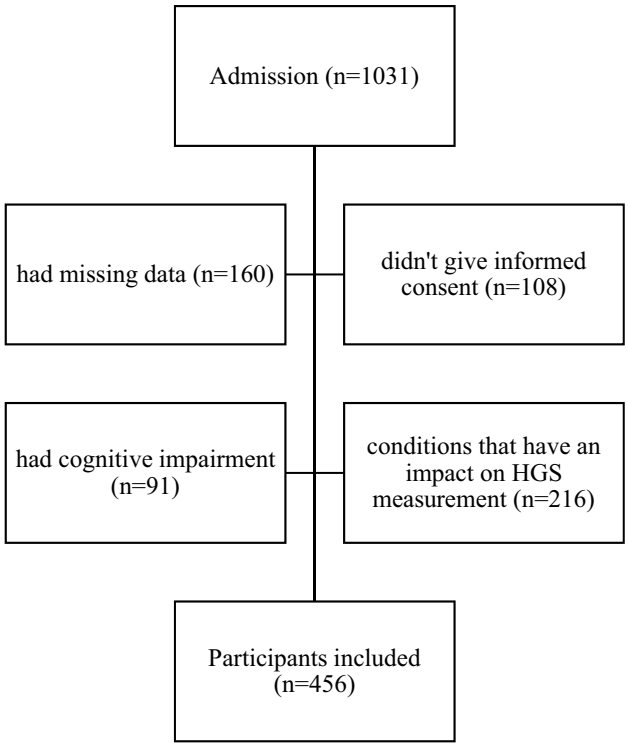


Fig. 1 Flow diagram for the number of participants included in the study

latter [median: 4 (min: 0, max: 10) vs. median: 5 (min: 1, max: 9) $p < 0.001$].

The presence of frailty ($p < 0.001$), malnutrition ($p < 0.001$), depression ($p = 0.016$), chronic kidney disease ($p = 0.004$), male sex ($p = 0.004$) and age ($p = < 0.001$) were all associated with probable sarcopenia (Table 2).

Multivariate analysis for the association of study variables and probable sarcopenia

The variables most commonly associated with probable sarcopenia in the univariate analysis ($p < 0.05$) were used as independent variables in the regression analysis. In Model 1, age (OR 1.120, 95% CI 1.072–1.170) and the male sex (OR 2.040, 95% CI 1.136–3.664) were both independently associated with probable sarcopenia. In Model 2 in which age, sex and malnutrition were added as independent variables, age (OR 1.119, 95% CI 1.071–1.170) and the male sex (OR 2.166, 95% CI 1.198–3.917) were independently associated with probable sarcopenia, while no independent relationship could be identified between malnutrition and probable sarcopenia (OR 1.548, 95% CI 0.820–2.923). In Model 3, we added age, sex, frailty, malnutrition, chronic kidney disease and depression as independent variables, and the presence of frailty (OR 4.265, 95% CI 2.200–8.267), male sex (OR 0.269, 95% CI 0.142–0.510) and chronic kidney disease (OR 3.084, 95% CI 1.105–8.608) were independently associated with probable sarcopenia (Table 3).

Table 1 Characteristics of the study population ($n = 456$)

	Male ($n = 132$)	Female ($n = 324$)
Age (years)[a]	75.6 ± 6.5	74.1 ± 6.6
Anthropometric data		
Height (cm)[a]	165 ± 6.7	151 ± 5.9
Weight (kg)[a]	76.7 ± 13.4	71.7 ± 14.4
BMI (kg/m^2)[a]	28.2 ± 4.4	31.2 ± 6
Number of illnesses[b]	4 (0–10)	4 (0–9)
Comorbidities [*n*, (%)]		
Hypertension	90 (68.7)	230 (71.4)
Diabetes mellitus	42 (32.1)	115 (35.7)
Congestive heart failure	7 (5.3)	12 (3.7)
COPD	15 (11.5)	14 (4.3)
Chronic kidney disease	6 (4.6)	15 (4.7)
Depression	22 (16.8)	72 (22.4)
Osteoporosis	11 (8.4)	74 (23)
Number of drugs[b]	6 (0–21)	5 (0–17)
Falls in past year	31.8%	45.4%
ADL score[b]	6 (4–6)	6 (1–6)
IADL score[b]	8 (0–8)	8 (0–8)
Nutritional status (MNA)		
Malnutrition	21.9%	25%
Normal nutrition	78.1%	75%
FRAIL score[b]	0 (0–5)	1 (0–4)
Frailty	24.2%	46.9%
Hand grip strength[a] (kg)	33.5 ± 7.4	21.2 ± 5.3
Gait speed[a] (m/s)	0.97 ± 0.2 (1)	0.86 ± 0.2 (0.89)
Chair sit to stand[a]	11.9 ± 4.2 (11)	13.4 ± 5.07 (11.9)
SPPB[b]	11 (4–19)	10 (2–12)
SARC-F total score[b]	0 (0–7)	1 (0–8)

COPD Chronic obstructive pulmonary disease, *ADL* activities of daily living, *IADL* instrumental activities of daily living, *SPPB* short physical performance battery

[a]Mean ± standard deviation

[b]Median (minimum–maximum)

Discussion

In the present study, we have investigated the associated factors of older adults who attended our geriatric outpatient clinic, and found the prevalence of probable sarcopenia to be 12.7%, while frailty, male sex and chronic kidney disease were identified as independent associates of sarcopenia.

Probable sarcopenia is a new term that was introduced to the literature with EWGSOP2 consensus [7], and so there have to date been only a limited number of studies of

Table 2 Univariate analysis for probable sarcopenia and related factors

Variables	Total $n=456$	Probable sarcopenia (+) $n=58$	Probable sarcopenia (−) $n=398$	P value
Male sex [n, (%)]	132 (28.9%)	26 (44.8%)	106 (26.6%)	0.004[a]
Diabetes mellitus [n, (%)]	157 (34.4%)	20 (34.5%)	137 (34.4%)	0.976
Hypertension [n, (%)]	320 (70.2%)	38 (65.5%)	282 (70.8%)	0.359
Depression [n, (%)]	94 (20.6%)	19 (32.7%)	75 (18.8%)	0.016[a]
Osteoporosis [n, (%)]	85 (18.6%)	13 (22.4%)	72 (18.1%)	0.446
Chronic kidney disease [n, (%)]	21 (4.6%)	7 (12.1%)	14 (3.5%)	0.004[a]
COPD [n, (%)]	29 (6.3%)	4 (6.9%)	25 (6.3%)	0.87
Congestive heart failure [n, (%)]	19 (4.2%)	4 (6.9%)	15 (3.8)	0.27
Frailty [n, (%)]	184 (40.3%)	39 (67.2%)	145 (36.4%)	<0.001[a]
Falls [n, (%)]	189 (41.4%)	27 (46.5%)	162 (40.7%)	0.39
Polypharmacy [n, (%)]	292 (64.6%)	43 (74.1%)	249 (62.6%)	0.104
Malnutrition [n, (%)]	107 (23.5%)	19 (32.7%)	88 (22.1%)	<0.001[a]

n number, *COPD* chronic obstructive pulmonary disease

[a]Statistically significant

Table 3 Logistic regression analysis for factors associated with probable sarcopenia

Factor	P value	Odds ratio	95% CI
Model 1			
Age[a]	<0.001	1.120	1.072–1.170
Sex[a]	0.017	2.040	1.136–3.664
Model 2			
Age[a]	<0.001	1.119	1.071–1.170
Male sex[a]	0.011	2.166	1.198–3.917
Malnutrition	0.178	1.548	0.820–2.923
Model 3			
Age[a]	<0.001	1.170	1.056–1.161
Male sex[a]	<0.001	0.269	0.142–0.510
Depression	0.121	1.688	0.871–3.270
Chronic kidney disease[a]	0.032	3.084	1.105–8.608
Frailty[a]	<0.001	4.265	2.200–8.267
Malnutrition	0.534	1.234	0.636–2.395

Model 1 = Hosmer and Lemeshow Model χ^2 (8) = 3.770; $p=0.877$, Model 2 = Hosmer and Lemeshow Model χ^2 (8) = 5.848; $p=0.664$, Model 3 = Hosmer and Lemeshow Model χ^2 (6) = 2.594; $p=0.858$

[a]Statistically significant

this topic [15, 27–31]. The prevalence of sarcopenia and probable sarcopenia varies according to the study location (community/institution), age group, race, gender distribution and diagnostic criteria/tools. Using the handgrip strength cutoff points proposed by the EWGSOP2 (males < 27 kg; females < 16 kg), several studies have reported a prevalence of probable sarcopenia of between 5.3 and 73% in different countries. For example, Dodds et al. reported an overall prevalence of 5.3% in a British cohort study named UK Biobank of community-dwelling participants aged 40–70 years with a mean age of 56.3 ± 8.1 years, and suggested that probable sarcopenia increased with age [15]. A cross-sectional study of community-dwelling older adults in Switzerland revealed the prevalence of probable sarcopenia to be 26.3% in females and 28% in males in a study based on a sample of adults aged 75 years and older, with a mean age of 83.6 ± 5.6 years [27]. Similarly, Sobestiansky et al. reported a prevalence of 73% for probable sarcopenia in Sweden among 85–89 year old community-dwelling males [28]. The close association between decreased muscular strength and age may explain why the prevalence of probable sarcopenia is higher than in our study population.

The associations of frailty and malnutrition with sarcopenia are well known. Most definitions consider frailty to

be a clinical condition in which an individual's vulnerability to increasing dependency and/or mortality increases when exposed to a stressor [32]. Physical frailty, known also as phenotypic frailty, is hypothesized to be caused by a multisystem biological decline, including weight loss, weakness and slow walking speed. In this regard, the importance of muscles cannot be overlooked [33]. Sarcopenia, by definition, is characterized by low physical performance, suggesting that the condition is a core contributor to physical frailty. Frailty and sarcopenia have a significant overlap in practice [34], although there has to date been only one study in the literature investigating the association between frailty and probable sarcopenia, which is identified with EWGSOP2 low HGS cutoffs. This study was a retrospective cross-sectional study that involved community-dwelling geriatric outpatients reported by our group and investigated specific associations between probable sarcopenia and measures of physical performance and frailty [35]. In that study, probable sarcopenia was found to be associated also with frailty (OR 20.9, 95% CI 8.3–53.0, $p < 0.001$) [35]. The early diagnosis of sarcopenia by probable sarcopenia could help in the determination of frailty in the early stage. Unfortunately, adverse outcomes such as falls, hospitalizations and mortality are much more common in frail elderly people [36], and so effective strategies targeting the prevention, early diagnosis and management of frailty in an aging population will likely reduce the burden of the condition both on the individual and, financially, on the healthcare system.

Malnutrition is a major factor in the pathogenesis of frailty and sarcopenia. Therefore, nutrition is considered a major point in the management of sarcopenia [37]. However, we could not find an independent relationship between malnutrition and probable sarcopenia in both Models, which is probably due to the low malnutrition rate in our patient population. In addition, worthy of note is the high proportion of overweight and obese older adults in our cohort.

Sarcopenia is considered "primary" (or age-related) when no other specific cause is prominent, and "secondary" when causal factors other than (or in addition to) aging are prominent [7]. Sarcopenia can occur as a consequence of systemic disease, particularly diseases that trigger inflammatory processes such as cancer or organ failure, like chronic kidney disease. With this in mind, in the present study we carried out univariate and multivariate analyses of chronic diseases that are common in older adults, such as hypertension, diabetes mellitus, chronic kidney disease (CKD), COPD, CHF, osteoporosis and depression. As a result, an independent association was identified only between probable sarcopenia and CKD. CKD is a catabolic state that is known to be associated with protein wasting and with multiple metabolic derangements [38]. There have been several studies related to sarcopenia and CKD in the literature [17, 39–43], but few examine the association between probable sarcopenia and CKD. In longitudinal studies of patients with CKD, low muscle strength (probable sarcopenia) was found to be a stronger predictor of increased hospitalization and mortality than lower muscle mass [17, 39, 40]. In a recent study, Wilkinson et al. investigated the prevalence of sarcopenia in individuals with CKD, its risk factors, and its association with all-cause mortality in the United Kingdom among participants of the UK Biobank study aged 56.1 ± 8.1 years. They found that 9.7% of those with CKD had probable sarcopenia, which was twice the prevalence of 5.0 percent in those without CKD (relative risk: 1.93, $p = 0.001$) [44]. Although the mean age of the participants in this study was lower, a relationship was found between probable sarcopenia and CKD, similar to the findings of the present study.

Diabetes is increasing worldwide and has emerged as a major public health issue in Turkey. At an alarming rate of increase, Turkey has highest prevalence of diabetes and obesity within Europe based on the data published by World Health Organization (WHO) [45]. In our sample, the prevalence of diabetes was 32.1% and 35.7% in the male and female participants, respectively. In a cross-sectional, population-based survey entitled Turkish diabetes epidemiology study 2 (TURDEP 2), the prevalence of newly diagnosed and previously known diabetes in those aged 75–79 years were 42.6% and 34% in the female and male respondents, respectively [46]. The prevalence in our study population is similar to that of Turkey. These high rates are not specific to our study population. Diabetes is known to increase the risk of sarcopenia development in older people. In the literature, the prevalence of sarcopenia in type 2 diabetes mellitus (T2DM) has been reported in a wide range, varying from 7 to 29.3% in different populations [47–49]. A recent meta-analysis that included 6,526 participants revealed the prevalence of sarcopenia to be significantly higher in T2DM than in non-diabetic individuals (OR 1.55; 95% CI 1.25–1.91; $p < 0.001$) [50]. In this study, T2DM patients had lower muscle performance and strength than normoglycemic patients, but no differences in terms of muscle mass [49]. A review of the literature on probable sarcopenia uncovered a study in which Dodds et al. identified a relationship between diabetes and probable sarcopenia (OR 1.49; 95% CI 1.45–1.55) [15], supported by a recent study from Colombia that also showed diabetes to be independently associated with probable sarcopenia (OR 1.32, 95% CI 1.11–1.56) [18]. Low-grade systemic inflammation and oxidative stress appear to be the key contributors to muscle strength deterioration in diabetic patients, although in the present study, no relationship was identified between probable sarcopenia and diabetes mellitus. In a recent narrative review, BMI was found to be significantly lower in T2DM cases with sarcopenia than in those without it, and many studies have reported that the prevalence of sarcopenia decreases significantly as BMI increases [51]. The absence of a relationship in the present

study may be attributable to the high mean BMI values in our participants. Similarly, in a study in Italy, 23.7% of sarcopenic and 30.8% of non-sarcopenic patients were found to be affected by diabetes ($p = 0.101$) according to the EWGSOP2 criteria [52].

The presence of sarcopenia has been reported to be related to higher HbA1c levels in previous studies, indicating poor glycemic control [44, 53], while the absence of any association between diabetes and probable sarcopenia in the present study may be due to the better glycemic control, although the lack of glycemic control data of the patients prevents further comment on this issue.

COPD and CHF are associated with sarcopenia in the literature [54, 55]. As mentioned before, low-grade systemic inflammation and oxidative stress may predominantly accelerate muscle loss. In our study, we could not find an association between them. Our study population had less comorbidity, lower malnutrition rate, and they were relatively less frail because of the administration to outpatient clinic based on their own request. Since all these parameters are important in the etiology of probable sarcopenia in COPD and CHF, no significant relationship was found. Moreover, in an attempt to control pulmonary inflammation during acute exacerbations, corticosteroid treatment is an important therapeutic choice in COPD. However, administration of systemic corticosteroids has been demonstrated to affect muscle mass and consequently muscle strength [56]. Similarly, hypoxia has shown to induce inflammatory responses and increase oxidative stress which may indirectly impact on muscle protein turnover and contribute to muscle wasting [57]. Within our study population, patients were not in the acute exacerbation, and they had mild-moderate disease severity. This also explains why we could not find an association between COPD and probable sarcopenia.

Depression was another factor that we examined for an association with probable sarcopenia but revealed no independent association. The pathophysiology of sarcopenia includes inactivity, bed rest, malnutrition, hormone deficiency and chronic inflammation. Sarcopenia and depression seem to share several common risk factors, such as physical inactivity and the upregulation of inflammatory cytokines [58]. In a recent study, Delibas et al. found HGS not to be associated with depression, neither in a univariate analysis nor a regression analysis of a group of 204 older adults aged 68.7 ± 5.2 years [59]. A lack of motivation induced by depression may lead to impaired physical performance, and consequently, a decrease in muscle strength. That said, the study by Byeon et al. found no correlation between the two clinical disorders, similar to the present study [60]. The severity and duration of depression may be factors that affect the association between probable sarcopenia and depression. An association between sarcopenia and depression would be more likely if the patient has more severe and long-lasting depression. In addition, our patient sample demonstrated fewer depressive symptoms as they were under treatment; however, we are unaware of their current emotional states.

Decreases in muscle mass, muscle strength and physical function and increases in fat mass are more prominent in males than in females [61]. Although older males have more absolute muscle strength than women of the same age, males experience a greater and faster loss of muscle strength with aging [12, 62, 63]. With aging and/or other diseases, testosterone deficiency leads to a more robust catabolic response in males than in females (e.g., sarcopenia and cachexia) [61]. Globally, a greater prevalence of sarcopenia is often observed in males [64]. In line with earlier studies, we identified an independent association between males and probable sarcopenia in all Models.

Our study has several strengths, including its sample of older adults aged > 65 years, which makes it superior to some other studies [15]. We examined the associations of probable sarcopenia with a wider range of the geriatric syndromes and common diseases that are prevalent among older adults and made a comparison with the findings of previous studies. This is the first study in Turkey to examine probable sarcopenia and associated factors, although several limitations should also be considered. First, being of cross-sectional design, the present study fell short of producing any definite information about cause-and-effect relationships. Second, the work was based on retrospective data, and the prevalence of missing data meant that we had to exclude a large number of participants, while several others were excluded due to the presence of conditions that could affect their grip strength, leading to potential selection bias. Third, the associated factors were self-reported by the participants, so different types of response biases may have been introduced. In addition, the sample comprised community-dwelling older adults who were admitted to a tertiary outpatient clinic, and so the findings cannot be generalized to the older adult population. In contrast to these limitations, the sample included older adults who presented to the outpatient clinic, and so it provides information on the geriatric outpatients that make up the everyday practice population of clinicians working with older adults, and this can be considered a further strength.

The present study has contributed to the current knowledge of the prevalence of probable sarcopenia in community-dwelling, non-hospitalized, older females and males. Probable sarcopenia was most significantly associated with frailty, which can thus be considered a valid marker of the condition. Our results suggest that frailty screening should be performed in the presence of probable sarcopenia, without waiting for a loss in muscle mass, so that the clinicians can introduce the appropriate measures promptly. Moreover, our study found chronic renal failure to be significantly associated with probable sarcopenia among a variety of

studied diseases that frequently accompany aging. It should be kept in mind that loss of muscle strength and function may increase due to the high prevalence of comorbid diseases in older adults. Action should be taken after measuring handgrip strength (probable sarcopenia) to prevent sarcopenia and related complications. Further studies are needed of conditions with the potential to accompany probable sarcopenia to alert physicians of the need to screen for probable sarcopenia in at-risk patients.

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Declarations

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