JVHS

Research Article

e-ISSN: 2147-7892

dergipark.org.tr/en/pub/inonusaglik

Evaluation of Frailty, Balance, and Dual-Task Performance in Sarcopenic and Asymptomatic Older Adults

Şeyma AKDAĞLI, Kırıkkale University, Health Sciences Institute, Kırıkkale, Türkiye

Meral SERTEL, 2Bursa Uludağ University, Health Sciences Faculty, Physiotherapy and Rehabilitation Department, Bursa, Türkiye, (Corresponding Author), fzt_meralaksehir@hotmail.com

Abstract

This study evaluated frailty, balance, and dual-task performance in older adults with sarcopenia, compared with asymptomatic individuals. A total of 62 community-dwelling older adults who were registered at a Family Health Center in Kırıkkale province were included in this cross-sectional study, comprising 31 individuals with sarcopenia and 31 asymptomatic controls. Demographic and clinical data were collected using a structured case report form. Nutritional status was assessed with the Mini Nutritional Assessment, frailty with the Clinical Frailty Scale, and cognitive status with the Standardized Mini-Mental State Examination. Balance and gait were evaluated using the Tinetti Balance and Gait Evaluation,; dual-task performance was assessed with the Dual Task Questionnaire,; and physical fitness was measured using the Short Physical Performance Battery. Sarcopenia status was determined using the SARC-F questionnaire, muscle strength was assessed withusing a hand dynamometer, and muscle mass was measured using bioelectrical impedance analysis. After controlling for age and body mass index, significant differences were found between the groups inbetween-group differences were found in arm and calf circumferences, handgrip strength, gait speed, chair stand timechair-stand time, balance scores, and both subscale and total scoresboth the subscale and total scores of the Short Physical Performance Battery ($p < .05$). Significant differences were also observed in Tinetti balance and gait scores, as well as in nutritional status and sarcopenia screening scores. Older adults with sarcopenia demonstrated lower muscle strength, poorer balance, slower gait speed, reduced physical performance, poorer nutritional status, and higher frailty levels compared to asymptomatic individuals. However, no significant difference was observed between the groups in dual-task performance. These findings emphasize the effects of sarcopenia on physical function.

Keywords: Balance, Dual-task Performance Frailty, Older Adults, Sarcopenia.

Citiation: Akdağlı, Ş., & Sertel, M. (2026). Evaluation of frailty, balance, and dual-task performance in sarcopenic and asymptomatic older adults. *Journal of İnönü University Vocational School of Health Services*, *14*(3), 712–729.

10.33715/inonusaglik.1862389

Submission Date: January 13, 2026 - Acceptance Date: September 26, 2026 - Publication Date: October 19, 2026

İNÖNÜ UNIVERSITY PRESS

Journal of İnönü University Vocational School of Health Services is a peer-reviewed open access journal.
© 2026 The Author(s). OPEN ACCESS

INTRODUCTION

With the growing elderly population, geriatric syndromes have also become an important issue in healthcare (Kim et al., 2019). Identifying the risk factors contributing to the development of geriatric syndromes, taking preventive measures, early detection, and developing effective treatment strategies are important in this regard (Reuben et al., 1995). Sarcopenia, frailty, falls, urinary incontinence, and malnutrition are among the commonly recognized geriatric syndromes (Reuben et al., 1995).

Sarcopenia is a progressive and widespread syndrome characterized by the loss of skeletal muscle mass and strength, which can lead to adverse outcomes such as physical disability, poor quality of life, and death (Delmonico et al., 2007; Goodpaster et al., 2006). The European Working Group on Sarcopenia in Older People (EWGSOP)has defined sarcopenia as "a progressive and generalized loss of muscle mass and function'(Cruz-Jentoft et al., 2010a). The decline in muscle mass and muscle function associated with sarcopenia leads to reduced physical performance, weakness, disability, and an increased risk of falls (Cruz-Jentoft et al., 2010b). Sarcopenia can develop due to a variety of factors. Examples include the aging process, suboptimal dietary intake, immobility, sedentary lifestyle, chronic diseases, and polypharmacy (Cruz-Jentoft et al., 2010a).

Sarcopenia is considered a marker of frailty and plays a key role in the development of physical decline (Hao & Guo, 2012; Morley et al., 2005). While sarcopenia is considered a disease, frailty is a geriatric syndrome; sarcopenia contributes to the development of physical frailty, whereas the frailty syndrome represents a much broader concept (Cruz-Jentoft et al., 2019). Low grip force and slow walking speed are significantly associated with sarcopenia and fragility (Cruz-Jentoft et al., 2019).

There is a cycle between muscle mass and functionality in the aging process: first loss of muscle mass, then skeletal muscle insufficiency, then decrease in muscle strength and restriction of functionality, as a result, a decrease in motion(mobility), loss of balance, and difficulty experiencing (Chien et al., 2008).In addition, as the age progresses, there may be losses in the vestibular system, proprioception, reaction -time losses, with the inadequacies in these systems, and loss of balance, and with the physiological effects of aging, the deterioration of normal walking, difficulty in maintaining balance and mobility may occur (Chandak et al., 2014; Onat et al., 2015).

In daily life, older adults usually need to fulfill more than one task at the same time, such as speaking and observing the environment while walking, and this parallel multitasking status is known to make more demand for older people's ability to postural balance (Wang et al., 2024). Previous studies have shown that the slow and unbalanced motor performance observed in the aging population may be closely related to declines in cognitive functions such as attention, executive function, abstraction, and spatial orientation (Merchant et al., 2021a, 2021b).

Sarcopenia, characterized by decreased muscle mass and muscle function in older adults, is closely related to frailty, balance disorders, and an increased risk of falling. However, the status of these parameters in asymptomatic elderly individuals and the changes in performance under dual duty have not been sufficiently investigated. This study aims to compare frailty, balance, and bilateral task performance between sarcopenic and asymptomatic elderly individuals, to evaluate the effects of sarcopenia on the aging process more holistically, and to provide scientific evidence for early intervention strategies.

MATERIAL AND METHOD

This was a cross-sectional, descriptive study. Between February 2024 and May 2024, among 642 individuals aged 65 and over living in Kırıkkale province, 70 individuals were excluded due to lack of time, difficulty descending stairs, or unwillingness to participate. A multi-stage selection process was followed to determine the individuals included in the study. In the first stage, 572 individuals aged 65 years or older who were registered at a Family Health Center in Kırıkkale province were evaluated according to the EWGSOP2 criteria. Sarcopenia-related measurements were interpreted according to established diagnostic criteria and guideline-based cut-off values. According to the EWGSOP2 consensus, reduced muscle strength indicates probable sarcopenia. Cut-off values for handgrip strength were defined as <16 kg for women and <27 kg for men. Gait speed was evaluated using a threshold of <0.8 m/s to indicate impaired physical performance. Muscle mass was assessed using skeletal muscle mass index (SMI), with cut-off values of <5.5 kg/m² for women and <7.0 kg/m² for men. These reference values were used to classify participants and ensure standardization and comparability with previous studies (Özbek, 2025). Following this screening, sarcopenia was diagnosed in 31 older adults, who were included in the sarcopenic study group.

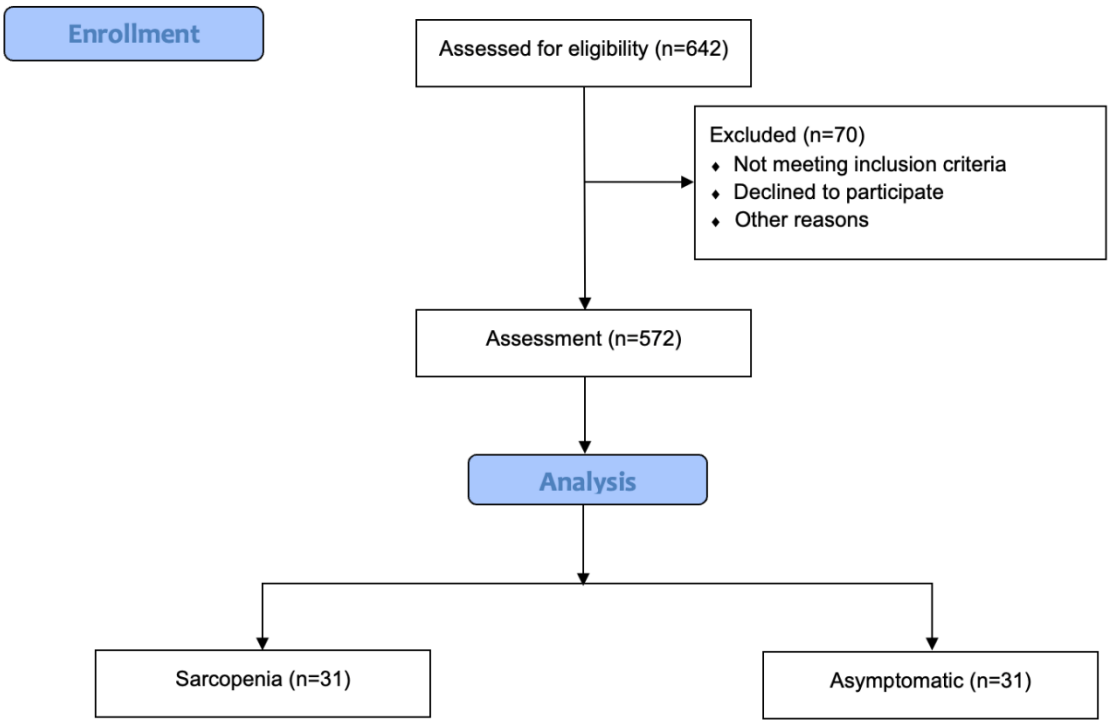
In the second stage, 31 older adults were recruited to establish the non-sarcopenic (asymptomatic) comparison group; they had demographic characteristics similar to those of the sarcopenic group, particularly age and sex. To facilitate access to healthy community controls and to ensure socio-demographic homogeneity between groups, snowball sampling was used. Using this method, healthy participants who initially met the inclusion criteria were asked to refer other potential participants of similar age and health status. As a result, a total of 31 sarcopenic and 31 asymptomatic older adults were included in the study. To reduce selection bias, care was taken to ensure that participants in both groups lived in the same geographic area and had similar socioeconomic status. The sample size was determined a priori using G*Power software (version 3.1.9.4). Because no previous studies reported effect sizes for the primary outcome in a comparable population, a conservative effect size was assumed for the power analysis. For an independent-samples t-test (two-tailed), assuming an alpha level of 0.05 and a power of 0.95, the minimum required sample size was calculated to be 62 participants (Figure 1). In addition, a post-hoc power analysis was conducted using the SARC-F total score as the primary outcome measure. The analysis demonstrated that the study was adequately powered, with statistical power ($1 - \beta$) of 0.9999, given the large observed effect size ($\eta p^2 = 0.89$).

This study was approved by the Non-Interventional Research Ethics Committee of Kırıkkale University (Meeting Date: 31.01.2024; Meeting No: 2024/02; Decision No: 2024.01.26). The study aims, procedures, and voluntary nature of participation were explained to all participants, who were older adults with sarcopenia, and written informed consent was obtained from each participant before data collection. The study was designed and conducted in accordance with the Declaration of Helsinki.

Participants aged 65 years and older who were willing to participate in the study and who scored 24 or higher on the Mini-Mental State Examination (MMSE) were included. Those under 65 years of age, those unable to communicate effectively, those unable to walk independently (e.g., using a wheelchair), those unwilling to participate, and those unsuitable for bioelectrical impedance analysis (such as individuals with a pacemaker) were excluded from the study.

Demographic data of the older adults (age, gender, height, weight, BMI calculated as body weight in kilograms divided by height in meters squared, occupation, etc.), and chronic diseases.

Figure 1. *Flow diagram of the study*



(hypertension, diabetes, chronic obstructive pulmonary disease, COPD, rheumatic diseases), medication use, smoking and alcohol habits, and use of assistive devices were collected using a case report form. Nutritional status was assessed with the Mini Nutritional Assessment(MNA)form, frailty with the Clinical Frailty Scale, cognitive status with the Standardized Mini-Mental Test, balance and gait with the Tinetti Balance and Gait Test, physical fitness with the Short Physical Performance Battery (SPPB),dual-task performance with the Dual Task Questionnaire, sarcopenia status with the SARC-F questionnaire, muscle strength using a Baseline hand dynamometer, and muscle mass with the InBody bioelectrical impedance device. All assessments were conducted face-to-face by an experienced physiotherapist in the clinic.

Muscle Mass Assessment

BIA: Estimates fat-free body mass. Cheap, easy-to-use, bedridden and standing patients. It has been used for more than 10 years and under standard conditions, BIA forecasts have been found with MR results (Lukaski et al., 1985). In addition, bioimpedance analysis (BIA) is a simple, low-cost technique for measuring regional muscle mass and has been shown to be particularly useful in epidemiological research across all body levels (Evans et al., 1995).

Anthropometric Measurements: Middle arm muscle circumference (MAMC-Midarm Muscle Circumflex) and CC-Calf Circumflex) Anthropometric measurements of functionality, general health status, nutrition adequacy, and survival in the elderly have been shown to foresee survival (Landi et al., 2010, 2014). For this reason, it can be used to screen for sarcopenia as an initial step and in community-based epidemiological studies. Calf circumference of 31 cm or less, and arm circumference of 23 cm or less in women and 24 cm or less in men have been reported to be associated with sarcopenia (Cruz-Jentoft et al., 2010b; Morley, 2008; Rolland et al., 2008).

Muscle Strength Assessment

Handgrip strength is more commonly used, and low handgrip strength correlates better with impaired mobility and adverse clinical outcomes than low muscle mass (T. N. Kim et al., 2013). In practice, a linear relationship was found between basal hand-squeezing power and dependence in daily life activities (Al Snih et al., 2002). Therefore, hand-squeezing power measurement is an effective and straightforward method for evaluating muscle strength (Cruz-Jentoft et al., 2010a). In our study, handgrip strength was measured using a Baseline digital hand dynamometer in accordance with the recommendations of the American Society of Hand Therapists. The measurement was performed in a seated position, with the shoulder adducted and in neutral rotation; the elbow flexed at 90 degrees; the forearm supported and in a neutral position; and the wrist in a neutral position. During the test, three measurements were taken with a one-minute rest interval between each, and the average value was recorded (Haidar et al., 2004). The final value for the dominant hand was taken from the three measurements.

Assessment of Physical Capacity

Gait speed is one of the primary parameters recommended for assessing physical capacity in diagnosing sarcopenia (Cruz-Jentoft et al., 2010a). For regular gait speed assessment, the participant is asked to walk 4 meters at their usual pace. The time taken to walk 4 meters is recorded in seconds. The test is performed twice; the best time is recorded by Lin et al. (2004).

Dual Task Questionnaire:

The Dual Task Questionnaire, developed by Evans et al., consists of 10 items and assesses the frequency of difficulties encountered during daily dual-tasking. It measures how often participants encounter problems described in the questionnaire. Respondents are asked to choose from five response options ranging from “very often” to “never” (Lindsay et al., 2004). The Turkish validity and reliability of the questionnaire were established by Sertel et al. (Sertel et al., 2021).

Tinetti Balance and Gait Test:

The Tinetti Balance and Gait Test assesses balance. The maximum scores for the gait and balance sections are 12 and 16 points, respectively, for a total of 28 points. Scores of 26 or below are considered indicative of balance problems. Studies have shown that the risk of falling increases as the score decreases. The test’s Turkish validity and reliability were established by Ağırcan (2009).

Clinical Frailty Scale:

It was developed to measure frailty in the second phase of the Canadian Study of Health and Aging (Topinková, 2008). The scale’s Turkish validity and reliability study was conducted by Özsürekçi et al.(2020).

The Clinical Frailty Scale is considered an effective tool for identifying frailty. The Clinical Frailty Scale assesses physical frailty by considering comorbidities, cognitive impairment, and disability. Scores on the scale range from 1 (very fit) to 9 (terminally ill). The degree of frailty is determined based on the description provided for each category (Topinková, 2008). The Clinical Frailty Scale defines light frailty (Category 5) as difficulty with 1 or 2 instrumental activities of daily living and moderate frailty (Category 6) as requiring assistance with 1 or 2 basic activities of daily living. The ‘serious fragile’ category (category 7) is defined as needing assistance with 3 or more basic activities of daily

living. According to the Clinical Frailty Scale, individuals classified as "very fit," "well," "managing well," and "vulnerable" are considered "non-frail," while those categorized as having mild, moderate, or severe frailty are classified as "frail" (Topinková, 2008).

Short Physical Performance Battery (SPPB):

The balance tests include tandem, semi-tandem, and side-by-side standing tests. Each test is demonstrated and explained to the participant. Support is provided until the participant assumes the correct foot position. The support is removed, and a stopwatch is started once the participant indicates readiness. The stopwatch is stopped if the participant moves their feet or seeks support, or if 10 seconds elapse. The test begins with the semi-tandem stance, in which the heel of one foot is placed beside the big toe of the other. The side-by-side standing test is administered if the participant cannot maintain the semi-tandem position for 10 seconds. If the participant maintains the semi-tandem position for 10 seconds, the tandem test follows, in which the heel of one foot is placed in front of the toes of the other foot. For the gait speed test, the participant is asked to walk 2.44 meters at their usual walking speed. If the participant uses an assistive walking device in daily life, they can use it during the test. The time taken to walk the distance is recorded. A straight-backed chair is placed near a wall in the chair stand test. The participant is asked to fold their arms across their chest, then stand up and sit down once. If successful, they are asked to perform five rapid sit-to-stand repetitions with their arms folded across their chests, and the time is recorded. The timer starts when the participant begins to stand and stops when they complete the fifth stand and are standing upright. The three physical performance tests (gait speed, balance, and chair stand) are scored from 0 to 4 based on the time taken to complete each test. The scores from the three tests are summed to obtain a total score ranging from 0 (poor performance) to 12 (excellent performance) (Guralnik et al., 1994).

SARC-F:

The SARC-F questionnaire, developed in 2018 for the rapid screening of sarcopenia, was recommended in the 2019 EWGSOP2 guidelines to identify patients suspected of having sarcopenia (Cruz-Jentoft et al., 2019). The SARC-F questionnaire includes items assessing strength, walking without support, rising from a chair or stool, climbing stairs, and the number of falls within the past year (Malmstrom & Morley, 2013). According to the EWGSOP2 guidelines, a score of 4 or higher on the SARC-F questionnaire indicates sarcopenia. The Turkish validity and reliability of the questionnaire were established by Kis (2019).

Mini Nutritional Assessment(MNA):

The full Mini Nutritional Assessment (MNA) consists of 18 items grouped into four sections: anthropometric assessment (BMI, weight, arm and calf circumferences); general assessment (lifestyle, medication use, mobility, signs of depression and dementia); short nutritional assessment (number of meals, food and fluid intake, nutritional autonomy); and subjective assessment (self-perception of health and nutrition) (Guigoz, 2006). The Turkish validity and reliability of the MNA were established by Sarıkaya (2013).

Statistical Analysis

Descriptive statistics for categorical variables were presented as frequencies and percentages. Differences between categorical variables were analyzed using the Pearson chi-square test and Fisher's exact test. The normality of numerical variables was assessed using the Shapiro-Wilk test. Descriptive statistics for numerical variables with normal distribution were expressed as mean ± standard deviation ($\bar{X}$ ± SD). Comparisons between two independent groups, controlling

for age and BMI (which were normally distributed), were performed using a one-way ANCOVA. In all calculations and interpretations, statistical significance levels were set at $p < 0.05$, $p < 0.01$, and $p < 0.001$, with two-tailed hypotheses. Statistical analyses were conducted using the SPSS software package version 27 (IBM Inc., Chicago, IL, USA).

RESULT

Among the sarcopenic participants included in the study, 67.7% were female, with a mean age of 73.68±6.23 years; among the asymptomatic participants, 51.6% were female, with a mean age of 67.90±3.33 years (Table 1).

Statistically significant differences between the study groups were observed for age, BMI, presence of chronic diseases, regular medication use, alcohol consumption, sleep problems, urinary incontinence, fear of falling, and use of assistive devices ($p<0.05$; $p<0.01$; $p<0.001$) (Table 1).

In group comparisons adjusted for age and BMI, statistically significant differences were found in the following parameters: "Left Arm Measurement" ($F=5.633$; $p<0.05$); "Right Calf Measurement"($F=4.461$; $p < 0.05$); "Right Hand Grip Strength"($F=6.929$; $p< 0.05$); "Left Hand Grip Strength"($F=8.284$; $p<0.01$); "Walking Speed Score" of the SPPB ($F=56.465$; $p< 0.001$); "Chair Stand Score"($F = 62.001$; $p < 0.001$); "Balance Score"($F=19.248$; $p<0.001$); "Total SPPB Score"($F=81.168$; $p < 0.001$); "Walking Speed"($F=45.695$; $p<0.001$); "Chair Stand Time"($F=93.967$; $p<0.001$); "Tinetti Balance Score"($F=36.659$; $p<0.001$); "Tinetti Gait Score"($F=5.263$; $p<0.05$); "Total Tinetti Score"($F=25.795$; $p<0.001$); "MNA Evaluation Score"($F=9.777$; $p<0.01$); "Total MNA Score"($F=4.940$; $p<0.05$); and "Total SARC-F Score" ($F=467.714$; $p<0.001$). (Table 2).

45.2% of sarcopenic participants were at the "managing well" level of clinical frailty, whereas 58.1% of asymptomatic individuals were at the "well" level of clinical frailty (Table 3).

A statistically significant difference was found in clinical frailty levels between the study groups ($p<0.001$)(Table 3).

Table 1. *Comparison of Socio-Demographic, Health, Habit, and Assistive Device Use Outcomes Between Sarcopenic and Asymptomatic Older Adult (continued)*

	Sarcopenic (n=31)		Asymptomatic (n=31)			
Gender	**n**	**%**	**n**	**%**	**t-χ^2-f**	**p**
Male	10	32,3	15	48,4	χ^2=1,676	0,196
Female	21	67,7	16	51,6		
Age (years) ($\bar{X} \pm SS$)	73,68±6,23		67,90±3,33		**χ^2=4,550**	**<0,001*** **
Occupation						
Housewife	21	67,7	16	51,6	χ^2=1,676	0,196
Retired	10	32,3	15	48,4		
BMI (kg/m²) ($\bar{X} \pm SS$)	33,38±6,55		29,80±5,22		**χ^2=2,375**	**0,021***
Muscle Mass ($\bar{X} \pm SS$)	25,70±5,40		26,77±5,12		χ^2=-0,799	0,427
Muscle Mass Index ($\bar{X} \pm SS$)	10,28±1,11		9,91±1,84		χ^2=0,950	0,346
Fat-Free Mass Index ($\bar{X} \pm SS$)	18,71±2,04		18,56±1,66		χ^2=0,315	0,754
Marital Status						
Married	19	61,3	24	77,4	χ^2=1,897	0,168
Single	12	38,7	7	22,6		

Education Level						
Primary School	20	64,5	18	58,1		
Secondary School	3	9,7	3	9,7		
High School	4	12,9	4	12,9	χ^2=6,677	0,154
University	1	3,2	6	19,4		
Other	3	9,7	0	0,0		
Having Children						
Yes	29	93,5	30	96,8	f=0,345	0,557
No	2	6,5	1	3,2		
Chronic Disease Status						
Yes	29	93,5	21	67,7	**χ^2=6,507**	**0,011***
No	2	6,5	10	32,3		
Type of Disease*						
Hypertension	28	90,3	16	51,6		
Diabetes	16	51,6	9	29,0	χ^2=0,591	0,898
Rheumatism	1	3,2	0	0,0		
Other	20	64,5	12	38,7		
Regular Medication Use						
Yes	29	93,5	20	64,5	**χ^2=7,884**	**0,005****
No	2	6,5	11	35,5		
Daily Medication Frequency						
Once a day	7	24,1	7	33,3		
Twice a day	16	55,2	11	52,4	χ^2=1,176	0,759
Three times a day	5	17,2	3	14,3		
Four times or more a day	1	3,4	0	0,0		
Smoking Status						
Yes	3	9,7	5	16,1	f=0,565	0,452
No	28	90,3	26	83,9		
Alcohol Use						
Yes	0	0,0	4	12,9	**f=4,207**	**0,040***
No	31	100,0	27	87,1		
Visual Impairment						
Yes	28	90,3	24	77,4	χ^2=1,908	0,167
No	3	9,7	7	22,6		
Eyeglass Use						
Yes	28	90,3	23	74,2	χ^2=2,763	0,096
No	3	9,7	8	25,8		
Sleep Problems						
Yes	19	61,3	10	32,3	**χ^2=5,248**	**0,022***
No	12	38,7	21	67,7		
Urinary Incontinence						
Yes	17	54,8	6	19,4	**χ^2=8,363**	**0,004****
No	14	45,2	25	80,6		
Fear of Falling						
Yes	23	74,2	9	29,0	**χ^2=12,658**	**<0,001*****
No	8	25,8	22	71,0		
Health Insurance Type						
Social Security Institution	24	77,4	18	58,1		
Self-Employed Pension Fund	1	3,2	2	6,5	χ^2=4,440	0,218
Green Card	1	3,2	0	0,0		
Retirement Fund	5	16,1	11	35,5		

**: multiple responses*

t: Independent Samples t-Test; χ^2: Pearson's Chi-Square Test; f: Fisher's Exact Test

**p<0,05; **p<0,01; ***p<0,001*

Table 2. *Comparison of VAS, right and left arm, calf, and hand grip measurement values, Mini-Mental State Examination, Dual Task Questionnaire, Short Physical Performance Battery, gait speed, chair stand time, Tinetti, Mini Nutritional Assessment, and SARC-F questionnaire scores between study groups adjusted for age and BMI. (continued)*

	Sarcopenic	Asymptomatic		
	$\bar{X} \pm SS$	$\bar{X} \pm SS$	F	p
VAS	5,19±1,91	4,36±2,13	0,279	0,601
Right Arm Circumference	31,39±3,82	29,31±3,37	3,656	0,061
Left Arm Circumference	31,39±3,99	29,18±3,35	**5,633**	**0,021***
Right Calf Circumference	38,84±5,10	35,94±3,78	**4,461**	**0,039***
Left Calf Circumference	38,61±4,52	36,00±3,69	3,987	0,051
Right Handgrip Strength	20,69±4,42	26,78±6,00	**6,929**	**0,011***
Left Handgrip Strength	18,92±4,55	26,02±6,90	**8,284**	**0,006****
MMSE	25,48±1,00	25,87±1,28	2,040	0,159
DTQ (Dual Task Questionnaire)	8,03±1,97	7,97±0,71	0,156	0,694
Gait Speed Score	2,48±0,77	4,00±0,00	**56,465**	**<0,001*****
Chair Stand Score	2,06±0,63	3,68±0,48	**62,001**	**<0,001*****
Balance Score	2,94±0,93	4,00±0,00	**19,248**	**<0,001*****
SPPB Total Score	7,48±1,81	11,68±0,48	**81,168**	**<0,001*****
Gait Speed (m/s)	0,66±0,12	0,94±0,10	**45,695**	**<0,001*****
Chair Stand Time (seconds)	15,07±1,47	11,08±0,69	**93,967**	**<0,001*****
Tinetti Balance Score	12,10±1,14	14,52±0,77	**36,659**	**<0,001*****
Tinetti Gait Score	10,42±1,88	11,90±0,30	**5,263**	**0,025***
Tinetti Total Score	22,52±2,42	26,42±0,89	**25,795**	**<0,001*****
MNA Assessment Score (Mini Nutritional Assessment)	13,39±1,17	14,48±0,90	**9,777**	**0,003****
MNA Screening Score (Mini Nutritional Assessment)	13,63±1,34	13,58±1,06	0,006	0,937
MNA Total Score	27,02±1,79	28,06±1,17	**4,940**	**0,030***
SARC-F Total Score	4,48±0,77	0,13±0,34	**467,714**	**<0,001*****

Analysis performed by One-Way ANCOVA adjusted for age and BMI; MMSE: Mini-Mental State Examination; DTQ: Dual Task Questionnaire;
SPPB: Short Physical Performance Battery; MNA: Mini Nutritional Assessment; SARC-F:(SARC-F Questionnaire).

**p<0,05; **p<0,01; ***p<0,001*

Table 3. *Clinical frailty levels according to study groups*

	Sarcopenic (n=31)		Asymptomatic (n=31)			
Clinical Frailty Level	**n**	**%**	**n**	**%**	χ^2	**p**
Very Fit	0	0,0	13	41,9	**46,348**	**<0,001*** **
Well	5	16,1	18	58,1		
Managing Well	14	45,2	0	0,0		
Vulnerable	12	38,7	0	0,0		

χ^2: *Pearson's Chi-Square Test*

****p<0,001*

DISCUSSION

Analysis of the results showed that sarcopenic individuals had worse muscle strength, muscle mass, grip force, physical capacity, walking speed, balance, and nutritional status than asymptomatic elderly individuals. The results for bilateral duty were similar to those for sarcopenic and asymptomatic elderly individuals. According to the Clinical Frailty Scale, there are differences between individuals' levels of frailty, and elderly individuals with sarcopenia are more frail than asymptomatic ones.

In a study conducted in Brazil, the average calf circumference of sarcopenic elderly individuals was lower than that of non-sarcopenic individuals (Esteves et al., 2020).In a study of the elderly aged 70-84 years, arm and calf circumference were significantly lower in the sarcopenic group (S. Kim et al., 2018).In this study, the "asymptomatic group" refers to healthy older adults who showed no signs of sarcopenia and whose muscle strength, muscle mass, and physical performance were within normal limits according to the EWGSOP2 (2019) criteria. These individuals were selected from community-dwelling older adults who were living independently, had preserved cognitive function (MMSE ≥ 24), and had socio-demographic characteristics similar to those of the sarcopenic group, with matching performed for age and sex.

Our findings showed that sarcopenic older adults had significantly higher body mass index (BMI) and greater arm and calf circumferences than the asymptomatic group. These findings suggest that sarcopenia should be evaluated not only by low muscle mass but also by changes in overall body composition. The coexistence of increased BMI and increased anthropometric measurements may indicate the clinical condition known as sarcopenic obesity. Beyond the classical definition of sarcopenia, our results suggest that sarcopenic obesity may occur in individuals with increased adipose tissue despite reduced muscle function and physical performance. However, BMI alone is not a sufficient indicator for the diagnosis of sarcopenic obesity; body fat percentage and fat distribution should also be assessed using specific threshold values, such as bioelectrical impedance analysis (BIA) or dual-energy X-ray absorptiometry (DEXA) (Prado et al., 2024). Since no direct classification based on fat mass analysis was performed in our study, these findings should be interpreted with caution.

An unexpected finding of the present study was that calf circumference was higher in the sarcopenic group than in the asymptomatic group. This result may be related to the significantly higher body mass index (BMI) in the sarcopenic

group. Previous studies have suggested that increased subcutaneous adipose tissue in older adults with higher fat mass may lead to overestimation of calf circumference and may mask underlying muscle loss (Özbek, 2025). In line with this, recent evidence indicates that calf circumference may have limited sensitivity in reflecting true muscle mass in the presence of increased adiposity (Özbek, 2024). Therefore, this finding may reflect adiposity's influence on anthropometric indicators of muscle rather than the true preservation of muscle mass.

These results emphasize that sarcopenia screening in older adults should include not only anthropometric measurements and conventional indicators but also comprehensive functional assessments. Future studies that examine the interactions among muscle quality, adipose tissue, and functional performance using more detailed parameters would provide a clearer understanding of this phenotype.

In our study, significant differences were observed between the sarcopenic individuals and the asymptomatic group in terms of age, body mass index (BMI), presence of chronic disease, regular medication use, and fear of falling. The literature emphasizes that balance and physical performance in older adults are determined not only by muscle mass or strength but also by the complex interaction of these clinical variables (Riviati & Indra, 2023).In particular, polypharmacy and chronic disease burden may independently contribute to impairments in balance and reduced mobility by disrupting neuromuscular control (Ribeiro et al., 2026).In addition, the higher prevalence of fear of falling observed in the sarcopenic group may directly affect individuals' dual-task performance and balance strategies, as previously reported in the literature(Li et al., 2024). Although these findings make it difficult to attribute the observed functional impairments entirely to sarcopenia, they suggest that sarcopenia is a central component that may further exacerbate this unfavorable clinical condition (Zhao et al., 2026).

In a study using BIA-measured lean body mass and handgrip strength for diagnosis, Castillo et al. reported sarcopenia prevalence rates of 4% in men and 3% in women aged 70-75 years, increasing to 16% in men and 13% in women aged 85 years and older (Castillo et al., 2003). In our study, asymptomatic individuals were, on average, younger than individuals with sarcopenia.

In a study conducted on older men residing in a nursing home, MNA-SF scores were found to be lower in sarcopenic older adults compared to asymptomatic elderly individuals (Bahat et al., 2010). In another study, MNA scores of sarcopenic older adults were found to be significantly lower compared to non-sarcopenic individuals, and poor nutritional status was reported to increase the risk of sarcopenia (Liguori et al., 2018). Similarly, in our study, MNA scores of sarcopenic older adults were lower than those of non-sarcopenic older adults. The significantly lower MNA scores in the sarcopenic group support the notion that nutritional status is an important risk factor in the development of sarcopenia. Inadequate intake of energy and protein impairs the maintenance of muscle mass and decreases muscle strength, thereby increasing the risk of sarcopenia. These findings highlight that combating sarcopenia requires physical activity and the assessment and improvement of nutritional status.

In a study, it was reported that sarcopenic individuals scored lower on the Tinetti Balance Assessment test compared to non-sarcopenic individuals and experienced more balance-related problems (Halil et al., 2014). In an assessment of 237 elderly individuals, balance scores in the sarcopenia group were significantly lower than in the asymptomatic group (M.-C. Kim et al., 2022). Previous studies have shown that individuals with sarcopenia perform worse on dynamic balance function tests compared to healthy older adults, and that sarcopenic individuals experience a significant decline in dynamic postural control during the aging process (Wang et al., 2023). In one study, sarcopenic older adults exhibited decreased gait speed and impaired balance compared to asymptomatic individuals. Another study conducted in China

also reported lower handgrip strength and reduced gait speed in sarcopenic elderly participants (Lima et al., 2025; Zeng et al., 2016). The finding that sarcopenic individuals had significantly lower scores for balance, gait speed, and handgrip strength indicates that sarcopenia is a systemic condition that directly affects muscle function and motor performance. Similarly, the literature reports declines in functional capacity, muscle strength, and muscle mass. These results emphasize that sarcopenia is not merely a structural impairment but also a condition that has clinically significant effects on an individual's mobility, balance, and ability to perform activities of daily living. Therefore, multidimensional functional assessments, including muscle strength, balance, and gait, are critical for sarcopenia screening and intervention programs.

During dual-tasking, individuals with sarcopenia exhibited decreased step frequency and significantly increased gait cycle duration and double support time. This pattern of change indicates that older adults experience notable alterations in gait and an impaired ability to maintain gait stability when performing an additional task while walking (Wang et al., 2024). In older adults, sarcopenia is not limited to muscle loss but is accompanied by complex impairments in motor-cognitive interactions. Recent literature (2023–2024) emphasizes that dual-task performance is a much more sensitive indicator than single-task performance for predicting physical disability and fall risk in frail individuals (Wang et al., 2023). In our study, the lack of significant differences in dual-task questionnaire scores between the groups may be explained by similarities in participants' cognitive characteristics. Indeed, recent findings from 2024 indicate that motor-motor dual tasks may lead to more pronounced gait deviations in sarcopenic individuals than cognitive-motor tasks (Wang et al., 2024). Current evidence suggests that frailty and sarcopenia are closely linked to cognitive and motor decline, and that dual-task or cognitively demanding movement interventions may influence outcomes in older adults. (Daly & Duque, 2017). This situation inevitably leads to balance problems. Although our study found decreased balance and physical function among sarcopenic individuals, their dual-task performance was notably similar to that of asymptomatic participants. This suggests that dual-task performance is related not only to muscle strength or physical capacity but also to neurocognitive mechanisms such as cognitive reserve, executive functions, and the allocation of attentional resources. The generally preserved cognitive function of individuals in our sample, or insufficient separation of mental and motor components within the dual-task test, may be factors influencing this result. Additionally, sarcopenic individuals may have adapted to the physical challenges encountered in daily life, enabling them to compensate for dual-task demands through alternative strategies.

This finding highlights the importance of considering cognitive functions in assessing dual-task performance. It suggests that absolute impairments in motor-cognitive dual tasks should not be expected, even in individuals diagnosed with sarcopenia.

A health study reported that sarcopenia increases the risk of physical disability and is a significant risk factor for mobility limitations and disability in advanced age (Baumgartner et al., 1998; Visser & Schaap, 2011). Sarcopenia has been reported to increase the prevalence of frailty among individuals with age-related muscle weakness (Park et al., 2007, 2009). A meta-analysis study revealed a high overlap between frailty and sarcopenia in hospitalized older adults, with these conditions leading to adverse outcomes, including mobility impairments, falls, and fractures (Ligthart-Melis et al., 2020). Compared with participants without sarcopenia, frail older adults with sarcopenia exhibited significantly poorer gait performance (Zhou et al., 2023). The finding in your study that sarcopenic older adults were frailer than asymptomatic individuals is both expected and consistent with the literature. Our study also demonstrated that levels of frailty in sarcopenic older adults were significantly higher than in asymptomatic individuals, supporting the strong association between sarcopenia and frailty. Sarcopenia contributes to the frailty process through decreased physical capacity, depleted energy reserves, and disrupted homeostatic balance. Reports in the literature indicate that loss of muscle

mass and strength reduces an individual's tolerance to stressors and increases frailty scores. This finding emphasizes the importance of early frailty screening in sarcopenic individuals and underscores the necessity for preventive rehabilitation interventions.

Limitations of the Study

This study has several limitations that should be considered when interpreting the findings. First, the cross-sectional design does not allow causal relationships between sarcopenia, balance impairment, and dual-task performance to be established. Second, the relatively small sample size may limit the generalizability of the results to the broader older adult population. Third, although snowball sampling was used to recruit the asymptomatic control group in order to achieve socio-demographic similarity, this method may have introduced selection bias.

In addition, potential confounding factors such as age, BMI, chronic disease burden, regular medication use, polypharmacy, and fear of falling may have independently influenced balance and functional performance outcomes. Although these variables were compared between groups, their combined effects may not have been fully controlled. Body composition was evaluated mainly through anthropometric measurements and clinical assessments. However, direct analysis of fat mass and fat distribution using methods such as bioelectrical impedance analysis (BIA) or dual-energy X-ray absorptiometry (DEXA) was not performed, limiting the interpretation of sarcopenic obesity.

Another important limitation concerns the assessment of dual-task performance. In this study, dual-task performance was evaluated primarily using questionnaire-based measures rather than by direct, objective gait-based analysis. Although this approach provides valuable information regarding perceived functional difficulty, it may not fully reflect real-time motor-cognitive interference during walking and balance tasks. Recent studies suggest that objective assessments involving motor-motor and cognitive-motor dual-task paradigms may be more sensitive in detecting subtle functional impairments in sarcopenic older adults. Therefore, future longitudinal studies with larger sample sizes, objective gait-based dual-task assessments, and more comprehensive body composition analyses are needed to better clarify the complex relationship between sarcopenia, balance, and functional decline.

CONCLUSION

This study revealed that older adults with sarcopenia exhibited significantly lower muscle strength, muscle mass, handgrip strength, physical capacity, gait speed, balance, and nutritional status than their asymptomatic peers. Although dual-task performance was similar between the groups, sarcopenic individuals were found to be frailer according to the Clinical Frailty Scale. These findings highlight the multifaceted impact of sarcopenia on the physical and functional health of older adults and emphasize the need for a comprehensive clinical assessment encompassing muscle function, nutritional status, and frailty levels. Early identification of sarcopenia and targeted interventions to prevent its progression are critical to preserving functional independence in older adults.

Ethics Committee Approval: Approval for data collection was obtained from the Non-Interventional Research Ethics Committee of Kırıkkale University. (Meeting Date: 31.01.2024; Meeting Number: 2024/02; Decision Number: 2024.01.26). The study was explained to elderly individuals with sarcopenia, and voluntary informed consent was obtained from the participants. This study was designed and conducted in accordance with the Declaration of Helsinki.

Conflict of Interest: None declared.

Peer-review: Externally peer-reviewed.

Author Contributions: ŞA: Conceptualization and study design, data collection, implementation of assessments, data analysis and interpretation, literature review, and drafting of the manuscript. MS: Methodology development, supervision of statistical analyses, interpretation of results, critical revision of the manuscript for important intellectual content, and overall scientific oversight.

Financial Disclosure: None.

Acknowledgements: None.

References

Ağırcan, D. (2009). *Tinetti Balance and Gait Assessment'ın (Tinetti Denge ve Yürüme Değerlendirmesi) Türkçeye uyarlanması, geçerlilik ve güvenilirliği* [Master's thesis, Pamukkale University]. Pamukkale University GCRIS. https://gcris.pau.edu.tr/handle/11499/1911

Al Snih, S., Markides, K. S., Ray, L., Ostir, G. V., & Goodwin, J. S. (2002). Handgrip Strength and Mortality in Older Mexican Americans. *Journal of the American Geriatrics Society, 50(7),1250-1256*. https://doi.org/10.1046/j.1532-5415.2002.50312.x

Bahat, G., Saka, B., Tufan, F., Akin, S., Sivrikaya, S., Yucel, N., Erten, N., & Karan, M. A. (2010). Prevalence of sarcopenia and its association with functional and nutritional status among male residents in a nursing home in Turkey. *The Aging Male, 13(3),211–214*. https://doi.org/10.3109/13685538.2010.489130

Baumgartner, R. N., Koehler, K. M., Gallagher, D., Romero, L., Heymsfield, S. B., Ross, R. R., Garry, P. J., & Lindeman, R. D. (1998). Epidemiology of sarcopenia among the elderly in New Mexico. *American Journal of Epidemiology, 147(8),755-763.* https://doi.org/10.1093/oxfordjournals.aje.a009520

Castillo, E. M., Goodman-Gruen, D., Kritz-Silverstein, D., Morton, D. J., Wingard, D. L., & Barrett-Connor, E. (2003). Sarcopenia in elderly men and women: The Rancho Bernardo study. *American Journal of Preventive Medicine, 25(3),226-231*. https://doi.org/10.1016/s0749-3797(03)00197-1

Chandak, P., Joshi, V., Nimbhore, S., Rairikar, S. A., Shyam, A. K., & Sancheti, P. K. (2014). Correlation of Lower Extremity Isometric Muscle Strength and Balance Performance in Community-Dwelling Elderly Females. Indian Journal of Physiotherapy and Occupational Therapy. *An International Journal, 8(2),5*. https://doi.org/10.5958/j.0973-5674.8.2.049

Chien, M.-Y., Huang, T.-Y., & Wu, Y.-T. (2008). Prevalence of sarcopenia estimated using a bioelectrical impedance analysis prediction equation in community-dwelling elderly people in Taiwan. *Journal of the American Geriatrics Society, 56(9),1710-1715*. https://doi.org/10.1111/j.1532-5415.2008.01854.x

Cruz-Jentoft, A. J., Baeyens, J. P., Bauer, J. M., Boirie, Y., Cederholm, T., Landi, F., Martin, F. C., Michel, J.-P., Rolland, Y., Schneider, S. M., Topinková, E., Vandewoude, M., & Zamboni, M. (2010a).Sarcopenia: European consensus on definition and diagnosis. *Age and Ageing, 39(4),412-423.* https://doi.org/10.1093/ageing/afq034

Cruz-Jentoft, A. J., Bahat, G., Bauer, J., Boirie, Y., Bruyère, O., Cederholm, T., Cooper, C., Landi, F., Rolland, Y., Sayer, A. A., Schneider, S. M., Sieber, C. C., Topinkova, E., Vandewoude, M., Visser, M., Zamboni, M., Bautmans, I., Baeyens, J.-P., Cesari, M., & Schols, J. (2019). Sarcopenia: Revised European consensus on definition and diagnosis. *Age and Ageing, 48(1), 16–31.* https://doi.org/10.1093/ageing/afy169

Cruz-Jentoft, A. J., Landi, F., Topinková, E., & Michel, J.-P. (2010b). Understanding sarcopenia as a geriatric syndrome. *Current Opinion in Clinical Nutrition and Metabolic Care, 13(1),1–7.* https://doi.org/10.1097/MCO.0b013e328333c1c1

Daly, R. M., & Duque, G. (2017). Improving muscle, mind and mobility through exercise and nutrition in old age. *Innovation in Aging, 1(Suppl. 1),1308–1309.* https://doi.org/10.1093/geroni/igx004.4791

Delmonico, M. J., Harris, T. B., Lee, J.-S., Visser, M., Nevitt, M., Kritchevsky, S. B., Tylavsky, F. A., Newman, A. B., & for the Health, Aging and Body Composition Study. (2007). Alternative Definitions of Sarcopenia, Lower Extremity Performance, and Functional Impairment with Aging in Older Men and Women: Sarcopenıa Indıces, Performance, And Agıng. *Journal of the American Geriatrics Society, 55(5),769-774*. https://doi.org/10.1111/j.1532-5415.2007.01140.x

Esteves, C. L., Ohara, D. G., Matos, A. P., Ferreira, V. T. K., Iosimuta, N. C. R., & Pegorari, M. S. (2020). Anthropometric indicators as a discriminator of sarcopenia in community-dwelling older adults of the Amazon region: A cross-sectional study. *BMC Geriatrics, 20(1),518*. https://doi.org/10.1186/s12877-020-01923-y

Evans, W. J., Chumlea, Wm. C., Guo, S. S., Vellas, B., & Guigoz, Y. (1995). Techniques of Assessing Muscle Mass and Function(Sarcopenia) for Epidemiological Studies of the Elderly. The Journals of Gerontology Series A: *Biological Sciences and Medical Sciences, 50A(Special),45-51.* https://doi.org/10.1093/gerona/50A.Special_Issue.45

Goodpaster, B. H., Park, S. W., Harris, T. B., Kritchevsky, S. B., Nevitt, M., Schwartz, A. V., Simonsick, E. M., Tylavsky, F. A., Visser, M., Newman, A. B., & for the Health ABC Study. (2006). The Loss of Skeletal Muscle Strength, Mass, and Quality in Older Adults: The Health, Aging and Body Composition Study. The Journals of Gerontology Series A: *Biological Sciences and Medical Sciences, 61(10),1059-1064.* https://doi.org/10.1093/gerona/61.10.1059

Guigoz, Y. (2006). The Mini Nutritional Assessment (MNA)review of the literature—What does it tell us? The *Journal of Nutrition, Health & Aging, 10(6),466-485*; discussion 485-487.

Guralnik, J. M., Simonsick, E. M., Ferrucci, L., Glynn, R. J., Berkman, L. F., Blazer, D. G., Scherr, P. A., & Wallace, R. B. (1994). A Short Physical Performance Battery Assessing Lower Extremity Function: Association With Self-Reported Disability and Prediction of Mortality and Nursing Home Admission. *Journal of Gerontology, 49(2), M85-M94*. https://doi.org/10.1093/geronj/49.2.M85

Haidar, S. G., Kumar, D., Bassi, R. S., & Deshmukh, S. C. (2004). Average versus Maximum Grip Strength: Which is more Consistent*? Journal of Hand Surgery, 29(1),82-84*. https://doi.org/10.1016/j.jhsb.2003.09.012

Halil, M., Ulger, Z., Varlı, M., Döventaş, A., Oztürk, G. B., Kuyumcu, M. E., Yavuz, B. B., Yesil, Y., Tufan, F., Cankurtaran, M., Saka, B., Sahin, S., Curgunlu, A., Tekin, N., Akçiçek, F., Karan, M. A., Atlı, T., Beger, T., Erdinçler, D. S., & Arıoğul, S. (2014). Sarcopenia assessment project in the nursing homes in Turkey. *European Journal of Clinical Nutrition, 68(6),690-694*. https://doi.org/10.1038/ejcn.2014.15

Hao, R., & Guo, H. (2012). Anorexia, undernutrition, weight loss, sarcopenia, and cachexia of aging. *European Review of Aging and Physical Activity, 9(2),119–127*. https://doi.org/10.1007/s11556-012-0103-7

Kis, H. C. (2019). *SARC-F ölçeğinin Türkçeye uyarlanması ve 65 yaş üzeri bireylerde geçerlilik çalışması* [Master's thesis, Acıbadem Mehmet Ali Aydınlar Üniversitesi]. https://openaccess.acibadem.edu.tr/handle/11443/748

Kim, K. J., Shin, J., Choi, J., Park, J.-M., Park, H. K., Lee, J., & Han, S.-H. (2019). Association of Geriatric Syndromes with Urinary Incontinence according to Sex and Urinary-Incontinence–Related Quality of Life in Older Inpatients: A Cross-Sectional Study of an Acute Care Hospital. *Korean Journal of Family Medicine, 40(4),235-240*. https://doi.org/10.4082/kjfm.18.0011

Kim, M.-C., Park, H.-S., Kim, H.-I., Park, J.-K., & Chung, D.-K.(2022).An analysis study of sarcopenia and locomotive syndrome in the old people using evaluation tool. *Journal of Exercise Rehabilitation, 18(4),256–263*. https://doi.org/10.12965/jer.2244234.117

Kim, S., Kim, M., Lee, Y., Kim, B., Yoon, T. Y., & Won, C. W. (2018). Calf Circumference as a Simple Screening Marker for Diagnosing Sarcopenia in Older Korean Adults: The Korean Frailty and Aging Cohort Study(KFACS). *Journal of Korean Medical Science, 33(20),e151*. https://doi.org/10.3346/jkms.2018.33.e151

Kim, T. N., Park, M. S., Lim, K. I., Choi, H. Y., Yang, S. J., Yoo, H. J., Kang, H. J., Song, W., Choi, H., Baik, S. H., Choi, D. S., & Choi, K. M. (2013). Relationships between sarcopenic obesity and insulin resistance, inflammation, and vitamin D status: The Korean Sarcopenic Obesity Study. *Clinical Endocrinology, 78(4),525-532*. https://doi.org/10.1111/j.1365-2265.2012.04433.x

Landi, F., Onder, G., Russo, A., Liperoti, R., Tosato, M., Martone, A. M., Capoluongo, E., & Bernabei, R. (2014). Calf circumference, frailty and physical performance among older adults living in the community. *Clinical Nutrition, 33(3),539-544*. https://doi.org/10.1016/j.clnu.2013.07.013

Landi, F., Russo, A., Liperoti, R., Pahor, M., Tosato, M., Capoluongo, E., Bernabei, R., & Onder, G. (2010). Midarm muscle circumference, physical performance and mortality: Results from the aging and longevity study in the Sirente geographic area(ilSIRENTE study). *Clinical Nutrition, 29(4),441-447*. https://doi.org/10.1016/j.clnu.2009.12.006

Li, J., Lim, J., Jo, H., & Kang, S. J. (2024). Effects of possible sarcopenia on physical fitness, gait, and fear of falling of older adults. *Iranian Journal of Public Health, 53(12),2714–2723*. https://doi.org/10.18502/ijph.v53i12.17314

Ligthart-Melis, G. C., Luiking, Y. C., Kakourou, A., Cederholm, T., Maier, A. B., & De Van Der Schueren, M. A. E. (2020). Frailty, Sarcopenia, and Malnutrition Frequently(Co-)occur in Hospitalized Older Adults: A Systematic Review and Meta-analysis. *Journal of the American Medical Directors Association, 21(9),1216-1228*. https://doi.org/10.1016/j.jamda.2020.03.006

Liguori, I., Curcio, F., Russo, G., Cellurale, M., Aran, L., Bulli, G., Della-Morte, D., Gargiulo, G., Testa, G., Cacciatore, F., Bonaduce, D., & Abete, P. (2018). Risk of malnutrition evaluated by Mini Nutritional Assessment and sarcopenia in noninstitutionalized elderly people. *Nutrition in Clinical Practice, 33(6),879–886*. https://doi.org/10.1002/ncp.10022

Lima, A. B. de, Henrinques-Neto, D., Scott, D., de Araújo Pinto, A., Dos Santos Ribeiro, G., Peralta, M., Miranda, K. A., Campos, P., & Gouveia, E. R.(2025).Relationship between physical function and sarcopenia in the older adults from Amazonas: A cross-sectional study. *PloS One, 20(3),e0320079*. https://doi.org/10.1371/journal.pone.0320079

Lin, M.-R., Hwang, H.-F., Hu, M.-H., Wu, H.-D. I., Wang, Y.-W., & Huang, F.-C. (2004). Psychometric comparisons of the Timed Up and Go, One-Leg Stand, Functional Reach, and Tinetti Balance Measures in community-dwelling older people. *Journal of the American Geriatrics Society, 52(8),1343–1348*. https://doi.org/10.1111/j.1532-5415.2004.52366.x

Lindsay, R., James, E. L., & Kippen, S. (2004). The Timed Up and Go Test: Unable to predict falls on the acute medical ward. *Australian Journal of Physiotherapy, 50(4),249–251*. https://doi.org/10.1016/S0004-9514(14)60115-X

Lukaski, H., Johnson, P., Bolonchuk, W., & Lykken, G. (1985). Assessment of fat-free mass using bioelectrical impedance measurements of the human body. *The American Journal of Clinical Nutrition, 41(4),810-817.* https://doi.org/10.1093/ajcn/41.4.810

Malmstrom, T. K., & Morley, J. E. (2013). SARC-F: A Simple Questionnaire to Rapidly Diagnose Sarcopenia. *Journal of the American Medical Directors Association, 14(8),531-532.* https://doi.org/10.1016/j.jamda.2013.05.018

Merchant, R. A., Chan, Y. H., Hui, R. J. Y., Tsoi, C. T., Kwek, S. C., Tan, W. M., Lim, J. Y., Sandrasageran, S., Wong, B. L. L., Chen, M. Z., Ng, S. E., & Morley, J. E. (2021a). Motoric cognitive risk syndrome, physio-cognitive decline syndrome, cognitive frailty and reversibility with dual-task exercise. *Experimental Gerontology, 150, 111362.* https://doi.org/10.1016/j.exger.2021.111362

Merchant, R. A., Goh, J., Chan, Y. H., Lim, J. Y., & Vellas, B.(2021b). Slow Gait, Subjective Cognitive Decline and Motoric Cognitive Risk Syndrome: Prevalence and Associated Factors in Community Dwelling Older Adults. *The Journal of nutrition, health and aging, 25(1),48-56.* https://doi.org/10.1007/s12603-020-1525-y

Morley, J. E. (2008). Sarcopenia: Diagnosis and treatment. *The Journal of Nutrition Health and Aging, 12(7),452-456.* https://doi.org/10.1007/BF02982705

Morley, J. E., Kim, M. J., Haren, M. T., Kevorkian, R., & Banks, W. A. (2005). Frailty and the aging male. *The Aging Male, 8(3–4),135–140*. https://doi.org/10.1080/13685530500277232

Onat, Ş. Ş., Delialioğlu, S. Ü., Özişler, Z., & Özel, S. (2015). Kliniğimizde yatarak rehabilitasyon programı uygulanan multipl skleroz hastalarının sosyodemografik ve klinik özellikleri. *Turkish Journal of Physical Medicine and Rehabilitation, 61(1),23–29.* https://doi.org/10.5152/tftrd.2015.70188

Özbek, İ. C. (2024). *Yaşlılarda sarkopeninin klinik pratikte tanı ve değerlendirme yöntemleri.* Celal Bayar Üniversitesi Sağlık Bilimleri Enstitüsü Dergisi, 11(4),500–502. https://doi.org/10.34087/cbusbed.1578569

Özbek, İ. C. (2025). Sarcopenia: The role of muscle strength, muscle mass, and physical performance. *Kırıkkale Üniversitesi Tıp Fakültesi Dergisi, 27(2),253–253*. https://doi.org/10.24938/kutfd.1686054

Özsürekci, C., Balcı, C., Kızılarslanoğlu, M. C., Çalışkan, H., Tuna Doğrul, R., Ayçiçek, G. S., Sümer, F., Karabulut, E., Yavuz, B. B., Cankurtaran, M., & Halil, M. G. (2020). An important problem in an aging country: identifying the frailty via 9 Point Clinical Frailty Scale. *Acta Clinica Belgica, 75(3),200–204.* https://doi.org/10.1080/17843286.2019.1597457

Park, S. W., Goodpaster, B. H., Lee, J. S., Kuller, L. H., Boudreau, R., de Rekeneire, N., Harris, T. B., Kritchevsky, S., Tylavsky, F. A., Nevitt, M., Cho, Y., & Newman, A. B. (2009). Excessive loss of skeletal muscle mass in older adults with type 2 diabetes. *Diabetes Care, 32(11),1993–1997*. https://doi.org/10.2337/dc09-0264

Park, S. W., Goodpaster, B. H., Strotmeyer, E. S., Kuller, L. H., Broudeau, R., Kammerer, C., de Rekeneire, N., Harris, T. B., Schwartz, A. V., Tylavsky, F. A., Cho, Y.-W. & Newman, A. B. (2007). Accelerated loss of skeletal muscle strength in older adults with type 2 diabetes. *Diabetes Care, 30(6),1507–1512.* https://doi.org/10.2337/dc06-2537

Prado, C. M., Batsis, J. A., Donini, L. M., Gonzalez, M. C., & Siervo, M. (2024). Sarcopenic obesity in older adults: A clinical overview. *Nature Reviews Endocrinology, 20(5),261–277*. https://doi.org/10.1038/s41574-023-00943-z

Reuben, D. B., Borok, G. M., Wolde-Tsadik, G., Ershoff, D. H., Fishman, L. K., Ambrosini, V. L., Liu, Y., Rubenstein, L. Z., & Beck, J. C. (1995). A Randomized Trial of Comprehensive Geriatric Assessment in the Care of Hospitalized Patients. *New England Journal of Medicine, 332(20),1345-1350*. https://doi.org/10.1056/NEJM199505183322007

Ribeiro, J. V. H., Oliveira, M. L. A., Gâmbaro, G. A., da Silva, R. A., Ngomo, S., de Oliveira, E., & Fernandes, K. B. P. (2026). Drug Burden Index and its association with postural balance and falls among community-dwelling older adults. *Frontiers in Medicine, 13, 1678855*. https://doi.org/10.3389/fmed.2026.1678855

Riviati, N., & Indra, B. (2023). Relationship between muscle mass and muscle strength with physical performance in older adults: A systematic review. *SAGE Open Medicine, 11, 20503121231214650.* https://doi.org/10.1177/20503121231214650

Rolland, Y., Czerwinski, S., Van Kan, G. A., Morley, J. E., Cesari, M., Onder, G., Woo, J., Baumgartner, R., Pillard, F., Boirie, Y., Chumlea, W. M. C., & Vellas, B. (2008). Sarcopenia: Its assessment, etiology, pathogenesis, consequences and future perspectives. *The Journal of Nutrition Health and Aging, 12(7),433-450.* https://doi.org/10.1007/BF02982704

Sarıkaya, D. (2013). *Geriatrik hastalarda Mini Nütrisyonel Değerlendirme (MNA)testinin uzun ve kısa (MNA-SF) formunun geçerlilik çalışması* [Medical specialty thesis, Hacettepe University]. https://openaccess.hacettepe.edu.tr/handle/11655/913

Sertel, M., Kocaman, A. A., Arslan, S. A., Demirci, C., & Ayçiçek, G. Ş. (2021). Investigation of the validity and reliability of the Turkish version of the Dual Task Questionnaire in older individuals. *Adnan Menderes Üniversitesi Sağlık Bilimleri Fakültesi Dergisi, 5(2),303–314.* https://doi.org/10.46237/amusbfd.870670

Topinková, E. (2008). Aging, disability and frailty. *Annals of Nutrition and Metabolism, 52(Suppl. 1),6–11.* https://doi.org/10.1159/000115340

Visser, M., & Schaap, L. A. (2011). Consequences of sarcopenia. *Clinics in Geriatric Medicine, 27(3),387-399.* https://doi.org/10.1016/j.cger.2011.03.006

Wang, C., Jin, B., & Lu, A.(2024). Effects of cognitive–motor and motor–motor dual tasks on gait performance in older adults with sarcopenia. *Healthcare, 12(12),1206.* https://doi.org/10.3390/healthcare12121206

Wang, C., Wang, B., Liang, J., Niu, Z., & Lu, A. (2023). Effects of multi-task mode on cognition and lower limb function in frail older adults: A systematic search and review. *Healthcare, 11(23),3012.* https://doi.org/10.3390/healthcare11233012

Zeng, P., Han, Y., Pang, J., Wu, S., Gong, H., Zhu, J., Li, J., & Zhang, T. (2016). Sarcopenia-related features and factors associated with lower muscle strength and physical performance in older Chinese: A cross sectional study. *BMC Geriatrics, 16, 45.* https://doi.org/10.1186/s12877-016-0220-7

Zhao, Y., Jiang, Y., Guo, Y., Pan, W., Tian, W., Tang, L., & Feng, X. (2026). Long-term impact of sarcopenia on functional decline and mortality in community-dwelling older adults: A systematic review and meta-analysis. *Frontiers in Nutrition, 12, 1652386.* https://doi.org/10.3389/fnut.2025.1652386

Zhou, Z., Huang, Y., Wang, J., Su, H., Tang, H., & Wang, Y. (2023). A novel digital biomarker of sarcopenia in frail elderly: New combination of gait parameters under dual-task walking. *Frontiers in Aging Neuroscience, 15, 1087318.* https://doi.org/10.3389/fnagi.2023.1087318