INTRODUCTION

The proportion of the geriatric population in society is gradually increasing. According to a World Health Organization report, the number of people aged ≥ 60 years, which was one billion in 2020, is expected to increase at an unprecedented rate to 2.1 billion by 2050. National data reveal that the older population will double by 2060. With an increase in the geriatric population, geriatric syndromes are of increasing importance. Geriatric syndromes are common, complex, and costly health conditions in older individuals. Sarcopenia, which causes physical disability with a progressive and generalized decrease in skeletal muscle strength and mass, is also defined as geriatric syndrome.

Association between Sarcopenia and Cognitive Functions in Older Individuals: A Cross-Sectional Study

Busra Yigit, Can Oner, Huseyin Cetin, Engin Ersin Simsek
Department of Family Medicine, the Health Sciences University Kartal Dr. Lutfi Kirdar City Hospital, Istanbul, Turkey

Background: Sarcopenia and cognitive disorders are frequently observed in older individuals. This study investigated the relationship between sarcopenia and cognitive function in this population.

Methods: This cross-sectional study included 201 participants aged >65 years in Istanbul between July 1, 2020 and January 31, 2021. We screened all participants using the SARC-F (strength, assistance with walking, rising from a chair, climbing stairs, and falls) questionnaire to determine the risk of sarcopenia. Handgrip strength and skeletal muscle mass of participants at risk were measured to diagnose sarcopenia. Sarcopenia severity was evaluated using a 4-m walking speed test. We evaluated the cognitive status of participants using the Standardized Mini-Mental Test (SMMT) and the Standardized Mini-Mental Test for the Untrained (SMMT-E).

Results: It was found that 10.9% (n=22) of participants was risky for sarcopenia and 6.0% (n=12) and 33.3% (n=4) had definite and severe sarcopenia, respectively. Examination of the association between cognitive impairment and SARC-F showed that 8.6% (n=14) of participants with normal cognitive function were at risk of sarcopenia compared to 20.5% (n=8) of participants with cognitive impairment (p=0.045). Evaluation of the relationship between cognitive function and sarcopenia status showed that 3.7% (n=6) of participants with normal cognitive function had sarcopenia compared to 15.4% (n=6) among participants with cognitive impairment (p=0.006).

Conclusion: The rate of sarcopenia was significantly higher in older individuals with cognitive than those with normal cognitive functions.

Key Words: Sarcopenia, Cognitive functions, Muscle strength, Older individuals

In general, 5%–13% of people aged 60–70 years and 11%–50% of people aged ≥ 80 years have sarcopenia. A systematic study, reported sarcopenia in at least one of 20 members of the community, with the incidence increasing to up to one in three in frail older individuals. Sarcopenia is associated with many clinical consequences such as falls, fractures, physical disability, and increased mortality, causing high personal, social, and economic burdens. Sarcopenia is also associated with many chronic and endocrine comorbidities such as diabetes mellitus, depression, and cardiovascular diseases. However, the relationship of sarcopenia with cognitive function remains unclear. Sarcopenia and cognitive disorders share many co-occurrence mechanisms, which has prompted researchers to investigate the relationship between cognitive and
Sarcopenia was diagnosed according to the European Working Group on Sarcopenia in Older People (EWGSOP2) criteria.\textsuperscript{3,4} We also screened all patients based on the SARC-F (strength, assistance with walking, rising from a chair, climbing stairs, and falls) questionnaire. We considered participants with a SARC-F total score ≥4 to be at risk for sarcopenia.\textsuperscript{10} The handgrip strength of patients with sarcopenia risk was evaluated using a Baseline Digital Smedley hand dynamometer. We asked the participants were asked to keep their elbows close to the body, flex the elbow to 90°, and grasp the dynamometer and squeeze as hard as possible. We used the highest value of three measurements for analysis. We defined probable sarcopenia as handgrip strength < 27 kg in male participants and < 16 kg in female participants.\textsuperscript{3,4}

We applied bioelectrical impedance analysis (BIA) to evaluate the skeletal muscle masses of participants with probable sarcopenia. Jannsen et al.\textsuperscript{11} defined skeletal muscle index (SMI) as the percentage of total body mass (skeletal mass/body weight × 100), and expressed SMI\textsuperscript{1} in units. A low SMI was considered normal if it was greater than one standard deviation from the sex-specific mean for young adults (18–39 years) based on data from the Third National Health and Nutrition Examination Survey (NHANES III). Patients with values one standard deviation below the mean were defined as having sarcopenia. The present study used cutoff values of < 37\% (for male) and < 27.6\% (for female), with participants with values these cutoffs categorized as having sarcopenia.\textsuperscript{3,4}

We conducted a 4-m walking speed test to evaluate the physical performance of the participants, with times ≤ 0.8 m/s indicating severe sarcopenia.\textsuperscript{3,4}

Cognitive function
We used the Standardized Mini-Mental Test (SMMT) and Standardized Mini-Mental Test for the Untrained (SMMT-E) to evaluate the cognitive status of the participants. Participants who correctly completed all test areas received the maximum total score of 30. We defined normal cognitive function as scores of ≥ 24 points, mild dementia as scores of 18–24, and severe dementia as scores ≤ 18.\textsuperscript{11,14}

Statistical analysis
Study data were analyzed using IBM SPSS Statistics for Windows, version 21.0 (IBM, Armonk, NY, USA). Descriptive criteria (frequencies, percentages, means, medians, standard deviations, and minimum-maximum values) were reported. We applied Kolmogorov-Smirnov tests to assess normality. Pearson and Spearman correlation tests were used to evaluate the relationships between continuous variables. Chi-square test was used. Statistical significance was set at p < 0.05.

RESULTS
This study included a total of 201 participants—44.3\% (n = 89) male and 55.7\% (n = 112) female. The mean age of the participants was 73.3 ± 6.0 years. Most the participants were married (69.2\%; n = 139), high school graduates (29.4\%; n = 59), and retired (61.7\%; n = 124). The mean BMI was 27.9 ± 4.1 kg/m\textsuperscript{2}. According to BMI classification, approximately half of the participants (46.8\%; n = 94) were overweight. The general characteristics of the participants are presented in Table 1.

In this study, 10.9\% (n = 22) of the participants were at risk for sarcopenia. To confirm the diagnosis of sarcopenia, we evaluated the participants’ muscle mass and handgrip strength, which showed that 6.0\% (n = 12) of the participants had definite sarcopenia. The results of walking tests to assess the sarcopenia severity revealed severe sarcopenia in 33.3\% (n = 4) of the participants (Fig. 1).

Examination of the relationship between demographic data and sarcopenia status showed a significant difference between the presence of sarcopenia and age. In this study, 16.7\% (n = 2) of participants with sarcopenia were aged ≥ 85 years compared to 3.2\%
Table 1. Demographic features of the study participants (n=201)

| Characteristic                        | Value         |
|---------------------------------------|---------------|
| Age (y)                               | 73.3 ± 6.0    |
| 65–74                                 | 109 (54.2)    |
| 75–84                                 | 84 (41.8)     |
| ≥ 85                                  | 8 (4.0)       |
| Sex                                   |               |
| Male                                  | 89 (44.3)     |
| Female                                | 112 (55.7)    |
| Education (y)                         |               |
| ≤ 8                                   | 97 (48.3)     |
| ≥ 9                                   | 104 (51.7)    |
| Marital status                        |               |
| Married                               | 139 (69.2)    |
| Single                                | 7 (3.5)       |
| Widow/divorced                        | 55 (27.4)     |
| Working status                        |               |
| Retired                               | 124 (61.7)    |
| Employed                              | 11 (5.5)      |
| Non-employed                          | 66 (32.8)     |
| Living condition                      |               |
| Alone                                 | 36 (17.9)     |
| Wife/husband and children             | 158 (78.6)    |
| Mother/father                         | 6 (3.0)       |
| Other                                 | 1 (0.5)       |
| Income (Turkish lira)                 |               |
| ≤ 2,200                               | 63 (31.3)     |
| ≥ 2,201                               | 138 (68.7)    |

Values are presented as mean±standard deviation or number (%).

(n = 6) of participants without sarcopenia (p = 0.041). We observed no significant differences between other demographic characteristics and sarcopenia (Table 2).

Evaluation of the cognitive functions of the participants using SMMT showed a mean SMMT score of 26.2 ± 3.3. While 80.6% (n = 162) of the group had a normal cognitive function, 19.4% (n = 39) showed impairment. Our examination of the association between cognitive impairment and SARC-F revealed that 8.6% (n = 16) and 20.5% (n = 8) of participants with normal cognitive function and cognitive impairment, respectively, were at risk of sarcopenia (p = 0.045). We next assessed the relationship between cognitive function and sarcopenia status, finding that 3.7% (n = 6) of participants with normal cognitive function were sarcopenic, compared to 15.4% (n = 6) of participants with cognitive impairment (p = 0.006) (Table 3).

**DISCUSSION**

This study aimed to determine the prevalence of sarcopenia and investigate the relationship between sarcopenia and cognitive function in older individuals. It was found that 10.9% (n = 22) of participants was risky for sarcopenia and that 6.0% of the participants had definite sarcopenia. The rate of sarcopenia was significantly higher in older individuals with cognitive impairment compared to those without cognitive impairment (15.4% vs. 3.7%).

Epidemiological studies on the prevalence of sarcopenia have reported sarcopenia in 5%–13% of people aged 60–70 years and 11%–50% of people aged > 80 years. Differences in sarcopenia definitions, cutoff values, measurement methods, and formulations have led to different prevalence reports in the literature. BIA underestimates fat mass, overestimates muscle mass, and shows a small margin of error in estimating skeletal muscle mass. Kim et al. reported sarcopenia frequencies of 14.2% in female and 5.1% in male based on the SMI. The authors also reported different sarcopenia frequencies using different methods to assess muscle mass. In our study, the overall incidence of sarcopenia was 5.9%, while it was 8.0% in female, and 3.3% in male. The frequency of sarcopenia was 25% in participants aged ≥ 85 years, with a signifi-
cant association between age and sarcopenia. Given the progressive decrease in muscle mass with age, this result was expected. However, the frequency of sarcopenia in our study was relatively low, even in those aged > 85 years. We attribute this finding to the living conditions of the older individuals in this study. Physical activity and obesity are important risk factors for sarcopenia. As our study area was an island, the inhabitants have high physical activity levels.

We observed no significant difference in the presence of sarcopenia between sexes. In their meta-analysis including 58,404 patients, Shafiee et al.\(^{17}\) reported a similar prevalence of sarcopenia between sexes, consistent with our findings. The relationship between sex and sarcopenia has been inconsistent in the literature. Some studies reported a higher reduction in muscle mass in male than in female.\(^{18,19}\) Iannuzzi-Sucich et al.\(^{20}\) reported the highest prevalence of sarcopenia (52.9%) in male aged > 80 years compared to 31.0% among female of the same age. Various endogenous and exogenous factors determine the prevalence of sarcopenia in both sexes. Hormonal changes that play a role in decreasing muscle mass occur more slowly in male than in female. After the menopause transition, the concentrations of sex steroids containing both estrogen and androgen decrease significantly. The reduction in sex steroids in male is much slower than that in female.\(^ {21}\)

In our study, the rate of sarcopenia was significantly higher in older individuals with cognitive impairments compared to those with normal cognitive functions. Ida et al.\(^ {22}\) reported a significant

---

**Table 2. Relationships between participant demographic characteristics and the presence of sarcopenia**

|                        | Non-sarcopenic (n = 189) | Sarcopenic (n = 12) | p-value |
|------------------------|--------------------------|---------------------|---------|
| Age (y)                |                          |                     |         |
| 65–74                  | 105 (55.6)               | 4 (33.3)            | 0.041   |
| 75–84                  | 78 (41.3)                | 6 (50.0)            |         |
| ≥ 85                   | 6 (3.2)                  | 2 (16.7)            |         |
| Sex                    |                          |                     | 0.166   |
| Male                   | 86 (45.5)                | 3 (25.0)            |         |
| Female                 | 103 (54.5)               | 9 (75.0)            |         |
| Education (y)          |                          |                     | 0.188   |
| ≤ 8                    | 89 (47.1)                | 8 (66.7)            |         |
| ≥ 9                    | 100 (52.9)               | 4 (33.3)            |         |
| Marital status         |                          |                     | 0.446   |
| Married                | 132 (69.8)               | 7 (58.3)            |         |
| Single                 | 7 (3.7)                  | 0 (0)               |         |
| Widow/divorced         | 50 (26.5)                | 5 (41.7)            |         |
| Working status         |                          |                     | 0.390   |
| Employed               | 11 (5.8)                 | 0 (0)               |         |
| Non-employed/retired   | 178 (94.2)               | 12 (100)            |         |
| Living condition       |                          |                     | 0.151   |
| Alone                  | 32 (16.9)                | 4 (33.3)            |         |
| Other                  | 157 (83.1)               | 8 (66.7)            |         |
| Income (Turkish lira)  |                          |                     | 0.151   |
| ≤ 2,200                | 57 (30.2)                | 6 (50.0)            |         |
| ≥ 2,201                | 132 (69.8)               | 6 (50.0)            |         |

Values are presented as number (%).

---

**Table 3. Relationship of cognitive function, sarcopenia risk and sarcopenia**

|                        | Cognitive function | p-value |
|------------------------|--------------------|---------|
|                        | Normal (n = 162)   | Impaired (n = 39) |
| Non-risky for sarcopenia (n = 179) | 148 (91.4) | 31 (79.5) | 0.045 |
| Risky for sarcopenia (n = 22) | 14 (8.6)  | 8 (20.5)  |
| Non-sarcopenic (n = 189) | 156 (96.3) | 33 (84.6) | 0.006 |
| Sarcopenic (n = 12)    | 6 (3.7)     | 6 (15.4)   |
relationship between sarcopenia and mild cognitive impairment (MCI) using the Japanese version of the SARC-F in a study of Japanese participants with diabetes. Another study showed that physical performance but no other markers of sarcopenia were independently associated with cognitive impairment. Lee et al. reported that sarcopenia was associated with MCI in older Korean female. Moreover, a recent meta-analysis showed evidence regarding the relationship between sarcopenia and cognitive impairment.

This study is one of a few to assess sarcopenia and cognitive function in the Turkish population. However, our study had some limitations. First, because of the study area, the findings cannot be generalized. The study area was an island near a large metropolis (Istanbul) and the participants had higher socioeconomic status and average life expectancy than those of the general population. Moreover, as motor vehicles are not allowed on the island, the physical movement capacity of the participants was also higher than that of the general population. Additionally, the MMT is a screening tool that cannot diagnose dementia. Finally, the cross-sectional design does not show causality.

In conclusion, the results of our study revealed the frequency of cognitive impairment in older individuals at risk of sarcopenia and/or those diagnosed with sarcopenia. With the rapid increase in the geriatric population, neuropsychiatric diseases have become a critical public health problem worldwide and in our country. The correlation between SARC-F and SMMT findings suggests that patients at risk of sarcopenia can also be assessed for cognitive impairment.

ACKNOWLEDGMENTS

CONFLICT OF INTEREST
The researchers claim no conflicts of interest.

FUNDING
None.

AUTHOR CONTRIBUTIONS

Conceptualization: BY, CO, HC, EES; Data curation: BY; Funding acquisition: BY, EES; Investigation: BY, CO; Methodology: CO, HC, EES; Project administration: BY; Supervision: CO, HC, EES; Writing-original draft: BY, CO, HC, EES; Writing-review & editing: BY, CO, HC, EES.

REFERENCES

1. World Health Organization. Ageing [Internet]. Geneva, Switzerland: World Health Organization; c2022 [cited 2022 May 20]. Available from: https://www.who.int/health-topics/ageing#tab=tab_1.
2. Turkish Statistical Institute (TUIK). Elderly statistics 2018 [Internet]. Ankara, Turkey: Turkish Statistical Institute; 2019 [cited 2022 May 20]. Available from: https://data.tuik.gov.tr/Bulten/Index?p=Istatistiklerle-Yasilar-2018-30699.
3. Cruz-Jentoft AJ, Baeyens JP, Bauer JM, Boirie Y, Cederholm T, Landi F, et al. Sarcopenia: European consensus on definition and diagnosis. Report of the European Working Group on Sarcopenia in Older People. Age Ageing 2010;39:412-23.
4. Cruz-Jentoft AJ, Bahat G, Bauer J, Boirie Y, Bruyere O, Cederholm T, et al. Sarcopenia: revised European consensus on definition and diagnosis. Age Ageing 2019;48:16-31.
5. Morley JE. Sarcopenia in the elderly. Fam Pract 2012;29(Suppl 1):44-48.
6. Cruz-Jentoft AJ, Landi F, Schneider SM, Zuniga C, Arañ R, Ara H, Boirie Y, et al. Prevalence of and interventions for sarcopenia in ageing adults: a systematic review. Report of the International Sarcopenia Initiative (EWGSOP and IWGS). Age Ageing 2014;43:748-59.
7. Mijnarends DM, Luiking YC, Halffs R, Evers S, Lenaerts E, Verlaan S, et al. Muscle, health and costs: a glance at their relationship. J Nutr Health Aging 2018;22:766-73.
8. Chang KV, Hsu TH, Wu WT, Huang KC, Han DS. Association between sarcopenia and cognitive impairment: a systematic review and meta-analysis. J Am Med Dir Assoc 2016;17:1164.e7-1164.e15.
9. Basile G, Sardella A. From cognitive to motor impairment and from sarcopenia to cognitive impairment: a bidirectional pathway towards frailty and disability. Aging Clin Exp Res 2021;33:469-78.
10. Noh JH, Jung HW, Ga H, Lim JY. Ethical guidelines for publishing in the Annals of Geriatric Medicine and Research. Ann Geriatr Med Res 2022;26:1-3.
11. Malmstrom TK, Morley JE. SARC-F: a simple questionnaire to rapidly diagnose sarcopenia. J Am Med Dir Assoc 2013;14:531-2.
12. Janssen I, Heymsfield SB, Ross R. Low relative skeletal muscle mass (sarcopenia) in older persons is associated with functional impairment and physical disability. J Am Geriatr Soc 2002;50:889–96.
13. Folstein MF, Folstein SE, McHugh PR. "Mini-mental state". A practical method for grading the cognitive state of patients for the clinician. J Psychiatr Res 1975;12:189-98.
14. Gungun C, Ertan T, Eker E, Yasar R, Engin F. Reliability and validity of the standardized Mini Mental State Examination in the World Health Organization; c2022 [cited 2022 May 20]. Available from: https://www.who.int/health-topics/ageing#tab=tab_1.
diagnosis of mild dementia in Turkish population. Turk Psikiyatri Derg 2002;13:273-81.

15. Janssen I, Heymsfield SB, Baumgartner RN, Ross R. Estimation of skeletal muscle mass by bioelectrical impedance analysis. J Appl Physiol (1985) 2000;89:465-71.

16. Kim TN, Yang SJ, Yoo HJ, Lim KI, Kang HJ, Song W, et al. Prevalence of sarcopenia and sarcopenic obesity in Korean adults: the Korean sarcopenic obesity study. Int J Obes (Lond) 2009;33:885-92.

17. Shafiee G, Keshtkar A, Soltani A, Ahadi Z, Larijani B, Heshmat R. Prevalence of sarcopenia in the world: a systematic review and meta-analysis of general population studies. J Diabetes Metab Disord 2017;16:21.

18. Landi F, Liperoti R, Fusco D, Mastropaolo S, Quattrococi D, Proia A, et al. Prevalence and risk factors of sarcopenia among nursing home older residents. J Gerontol A Biol Sci Med Sci 2012;67:48-55.

19. Halil M, Ulger Z, Varli M, Doventas A, Ozturk GB, Kuyumcu ME, et al. Sarcopenia assessment project in the nursing homes in Turkey. Eur J Clin Nutr 2014;68:690-4.

20. Iannuzzi-Sucich M, Prestwood KM, Kenny AM. Prevalence of sarcopenia and predictors of skeletal muscle mass in healthy, older men and women. J Gerontol A Biol Sci Med Sci 2002;57:M772-7.

21. Juhl A, Skakkebaek NE. Androgens and the ageing male. Hum Reprod Update 2002;8:423-33.

22. Ida S, Nakai M, Ito S, Ishihara Y, Imataka K, Uchida A, et al. Association between sarcopenia and mild cognitive impairment using the Japanese version of the SARC-F in elderly patients with diabetes. J Am Med Dir Assoc 2017;18:809.e9-809.e13.

23. Moon JH, Moon JH, Kim KM, Choi SH, Lim S, Park KS, et al. Sarcopenia as a predictor of future cognitive impairment in older adults. J Nutr Health Aging 2016;20:496-502.

24. Lee I, Cho J, Hong H, Jin Y, Kim D, Kang H. Sarcopenia is associated with cognitive impairment and depression in elderly Korean women. Iran J Public Health 2018;47:327-34.

25. Peng TC, Chen WL, Wu LW, Chang YW, Kao TW. Sarcopenia and cognitive impairment: a systematic review and meta-analysis. Clin Nutr 2020;39:2695-701.