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Attention to Osteosarcopenia in Older People! It May Cause Cognitive Impairment, Frailty, and Mortality: A Cross-sectional Study

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Abstract

Objective: Osteosarcopenia is a relatively new defined syndrome in older people, elucidated as the coexistence of osteoporosis and sarcopenia. As this syndrome is newly defined, the interaction between physical dependence, frailty and mortality in older adults is not clear. To determine whether osteosarcopenia (OSP) has a greater effect on daily living activities, frailty, mortality, comorbidities than osteoporosis (OP) and sarcopenia (SP) alone.

Materials and Methods: The study included patients aged 65 and over who underwent bone mineral densitometry (BMD) and bioelectrical impedance tests. According to World Health Organization criteria, the osteoporosis group was included as BMD femoral neck T-score of -2.5 and below. The diagnosis of sarcopenia was done according to the criteria of the, "European Working Group on Sarcopenia of Older People 2018". Mortality detection was performed using the ''TC Turkey Ministry of Health Public Health Agency of Death Reporting System''. Comprehensive geriatric assessment, comorbidities and clinical frailty scores of the patients were recorded.

Results: The mean age of 306 patients (199 women, 65%) was 76.93±7.03. The prevalence of each category (non-sarcopenic non-osteoporotic, OP, SP and OSP) was 40.8%, 17.0%, 19.0% and 23.2%, respectively. Katz, Lawton-Brody, mini-mental state exam and mini nutritional assessment scores were significantly lower in the OSP group (p=0.014; 0.005; <0.001; <0.001, respectively). The clinical frailty score was highest in OSP, consistent with frailty (p=0.001). Seventy-three (23.8%) of 306 patients died. Mortality was highest in OSP (37%, p=0.014). In the logistic analysis, presence of type 2 diabetes mellitus increased the risk of osteosarcopenia (β: 2.701, p=0.004).

Conclusion: Osteosarcopenia maybe associated with physical and cognitive dependence, frailty and mortality in older people. Osteoporosis and sarcopenia should be screened together and preventive measures should be taken before they become serious.

Keywords: Osteosarcopenia, frailty, comprehensive geriatric assesment, mortality, cognitive impairment

Introduction

The world is aging and the prevalence of chronic diseases, including osteoporosis and sarcopenia, is increasing in older adults. Recognition and treatment of geriatric syndromes and chronic diseases, which are the most common causes of morbidity and mortality in older adults, will enable them to complete their life in a healthy way. In 2009, Binkley and Buehring (1) described a new geriatric syndrome in the elderly. They named this subgroup as sarco-osteoporosis. This new syndrome eventually became known as osteosarcopenia (OSP) (2,3). The pathophysiology of OSP and the understanding of coexisting disease groups will be useful for fall and fracture prevention strategies at the beginning of the most important problems for older adults (4). Some studies have confirmed that

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sarcopenia and osteoporosis (OSP) share common risk factors and that biological pathways and OSP are associated with significant physical disability, which poses an important threat to loss of independence in later life (4).

OSP is the combination of two conditions that affect the quality of life of older people. Patients with OSP have greater risk of dependence, falls, prevalence of fractures and death (5-7). In order to provide comprehensive care for older adults, especially musculoskeletal health, clinicians should also consider OSP. This topic has been the focus of interest in many studies due to its relatively new definition compared to other geriatric syndromes and due to its importance (8-10). It should not be ignored that the combination of these two conditions may cause dependency in daily basic and instrumental life activities and should be screened.

Our aim in this study was to determine whether OSP interacts with daily living activities, frailty, mortality, comorbidities and laboratory values.

Materials and Methods

Study participants

This cross-sectional study included patients aged 65 and over who underwent bone mineral densitometry (BMD) and bioelectrical impedance (BIA) tests between 2013 and 2019. Demographic data (age, sex, comorbidities), comprehensive geriatric assesment results and laboratory values were recorded in their hospital files. Patients whose data were incomplete in the file (those who were not suitable for BIA, BMD images were not transferred to the system, laboratory values were missing, comprehensive geriatric assesment tests could not be performed or were missing) were not included in the study. Mortality detection was performed using the "TC Turkey Ministry of Health Public Health Agency of Death Reporting System" (11). Mortality screenings of the patients were performed within 1 year after their measurements. Mortality status was compared on a case-by-case basis as a percentage. Patients were divided into 4 groups according to BIA and BMD data; group 1: Non-osteoporotic, non-sarcopenicgroup; group 2: Osteoporotic group (BMD value-2.5 and below); group 3: Sarcopenic group [sarcopenia was diagnosed according to the definition of the European Working Group on Sarcopenia of Older People 2018 (EWGSOP)]; group 4: Osteosarcopenic (OSP) group (taken as a coexistence of osteoporosis and sarcopenia status).

Bone mineral density and sarcopenia measurement

Bone mineral density was measured using DXA (HologicExplorer S/N 90704). According to World Health Organization (WHO) criteria, the osteoporosis group was included as BMD femoral neck T-score of -2.5 and below (12). The diagnosis of sarcopenia was done according to the criteria of the, "European Working Group on Sarcopenia of Older People 2018" (13). For muscle mass measurement, BIA; for muscle strength measurement, handgrip strength; for physical performance evaluation, gait speed measurement (m/sn) were used. BIA was performed with a portable BIA analyzer in supine position. Quadscan 4000 (Bodystat, Douglas, Isle of Man, UK) was used to obtain the BIA resistance in ohms (Ω). The device was set for the participant's age, gender, height and body weight. Skeletal muscle mass (SMM) was calculated according to the formula suggested by Janssen et al. (14). Low muscle mass was calculated according to the values indicated in studies on Turkish populations. In this study, values less than 9.2 kg/m^2 in men and 7.4 kg/m^2 in women were taken as low muscle mass (15).

The diagnosis of sarcopenia was made according to the revised European consensus on the definition and diagnosis "EWGSOP-2" (13). Three components are used in diagnosis:

1- Muscle strength: Muscle strength was measured with the hand grip test in our study, as mentioned in the comprehensive geriatric assessment section above. Local cut-off values were used as recommended by EWGSOP-2 (grip strengths of <22 kg for females and <32 kg for males).

2- Muscle quantity: Skeletal muscle mass was evaluated by BIA. The measurement was carried out in the supine position in the morning before breakfast after all of the participant's metal items were removed. Four electrodes of the device were fixed to the right foot and right hand of the individual, two for each, with the adhesive tape of the device itself in accordance with the measurement protocol. After entering the individual's age, gender, height, and body weight into the device, the measurement was made at a frequency of 50 kHz. Resistance value in ohms, which is one of the data items obtained from the analysis, was used to calculate skeletal muscle mass. The resistance value measured during the analysis was used in the following formula to calculate skeletal muscle mass, as proposed by Janssen et al. (14): [(height^2/resistance value in BIA measurement x 0.401) + (gender x 3.825) + (age x -0.071)]+5.102 (height in meters, resistance in ohms, for gender part 1 for male and 0 for female). The value obtained by this formula was divided by the square meter of the participant's height to obtain absolute skeletal muscle mass. An absolute skeletal muscle mass value of <7.4 kg/m^2 in females and <9.2 kg/m^2 in males corresponds to reduced skeletal muscle mass (15).

3- Physical performance: Gait speed was used in this study (≤0.8 m/s for men and women).

Those with low muscle strength were defined as probable sarcopenia. If low muscle strength was supported by the measurement (low skeletal muscle mass), the diagnosis of confirmed sarcopenia was made. If low physical performance was added to these, severe sarcopenia was diagnosed.

Definition of frailty

In the assessment of frailty, clinical frailty scores were used. In this scoring, high values are associated with frailty (16). There are nine categories: 1: Very fit- robust, active, energetic, well-motivated and fit; these people commonly exercise regularly and are in the most fit group for their age. 2: Fit- without active disease, but less fit than people in category 1. 3: Well, with treated comorbid disease- disease symptoms are well controlled compared with those in category 4. 4: Apparently vulnerable- although not frankly dependent, these people commonly complain of being ''slowed up'' or having disease symptoms. 5: Mildly frail- with limited dependence on others for instrumental activities of daily living. 6: Moderately frail- help is needed with both instrumental and non-instrumental activities of daily living. 7: Severely frail- completely dependent on others for activities of daily living, but not at high risk of dying within 6 months. 8: Very severely frail- completely dependent on others for activities of daily living and approaching end of life. 9: Terminally ill- approaching end of life with life expectancy <6 months. The ADL and IADL methods used in this scale were used as described above.

Laboratory values

As laboratory values (unit-normal range): Fasting blood glucose (mg/dL 74-100), calculated glomerular filtration rate (mL/min/1.73 m^2>60), calcium (mg/dL 8.8-10.6), total protein (g)/L 66-83), albumin (g/L 35-52), leukocyte (white blood cell) (x10^9/L 4.5-11), hemoglobin (g/dL 11.7-16.1), vitamin B12 (pg/mL 126.5-505), thyroid-stimulating hormone (µIU/mL 0.38-5.33), C-reactive protein (CRP) (mg/L 0.0-5.0), 25-hydroxy vitamin D (µg/L 10-60) were recorded. Biochemical parameters were studied using spectrophotometric, CRP turbidimetric, hormonal tests using ECLIA method, and vitamin D levels using HPLC method in Ankara University İbn-i Sina Hospital Laboratories.

Comprehensive geriatric assessment

Comprehensive geriatric assessment tests included the Katz activities of daily living index (ADL), Lawton instrumental activities of daily living scale (IADL), mini-mental status examination (MMSE), geriatric depression scale (short form of 15 questions) and mini-nutritional assessment-short form (MNA-SF). Daily life activities were evaluated with Katz ADL. This index evaluates the functions of dressing, bathing, going to the toilet, getting out of bed, eating and continence, over 6 points (17). Instrumental daily living activities were evaluated using the Lawton IADL. In this scale, activities such as telephone use, shopping, food preparation, household chores, laundry, urban transportation and proper use of drugs are evaluated over eight points (18,19). Cognitive functions were investigated by MMSE. Low scores on this test, which is evaluated over 30 points, indicate impairment in cognitive functions (20,21). The 15-item short form of geriatric depression was used (22). Nutritional status was investigated by MNA-SF. This test has validity and reliability in Turkey: Malnutrition between 0-7 points, malnutrition risk between 8-11 points and normal nutrition between 12-14 points (23,24). Hand grip strength measured by an electronic hand dynamometer (GRIP-D, influenza strength dynamometer, produced by Takei, made in Japan). The unit of results is kilograms. <22 kg for women and <32 kg for men were evaluated in favor of reduced muscle strength (15). Muscle performance was assessed by gait speed measured on a 4-meter course. After walking time was measured with an electronic stopwatch, the walking speed was calculated with the formula 4 meter/walking time (seconds) in m/s. The walking speed was evaluated in favor of decreased muscle performance as ≤0.8 m/sec (15).

Statistics

Statistical analyses were performed using ''Statistical Package for Social Sciences (SPSS) for Windows 24 (IBM SPSS Inc, Chicago, IL)''. The suitability of variables to normal distribution was examined using visual (histogram and probability graphs) and analytical methods (Kolmogorov-Smirnov/Shapiro-Wilk tests). Descriptive analyses were performed using mean and standard deviation for normally distributed variables, and median and maximum-minimum values for non-normally distributed variables. The frequency of categorical variables was expressed as (%). Chi-square and ANOVA tests were used for evaluation between groups in Table 1. Bonferroni post hoc tests were performed. Logistic regression was performed to determine associations [odds ratio (OR) and 95% confidence interval] between osteoporosis, sarcopenia and OSP, while adjusting for potential confounders including age and sex.

Results

The mean age of the 306 patients included in the study was 76.93±7.03 years. 199 (65%) were female. The prevalence of each category (non-sarcopenic non-osteoporotic, osteoporosis only, sarcopenia only and OSP) was 40.8%, 17.0%, 19.0% and 23.2%, respectively. Probable sarcopenia was 3.92% (n=12), confirmed sarcopenia was 10.45% (n=32) and severe sarcopenia was 4.57% (n=14). In the comparison between groups, the mean age of the OSP group was significantly higher than the other groups (79.41±7.21, p<0.001). Katz ADL, Lawton-Brody IADL, MMSE score, MNA-SF scores were significantly lower in the OSP group (p-values were 0.014; 0.005; <0.001; <0.001, respectively). Interactions between groups are specified in Table 1. Handgrip strength (kg) was significantly lower in the OSP group (p<0.001). Clinical frailty scores were found to be the highest in the OSP group (p=0.001). When the mortality of the patients were examined, 73 (23.8%) of 306 patients died. Mortality rate was significantly higher in the OSP group

Table 1. Comparison of patient comorbidities, comprehensive geriatric assessment tests and laboratory tests

	Non-sarcopenic non-osteoporotic n (%)	OP n (%)	SP n (%)	OSP n (%)	All	p*
n (%)	125 (40.8)	52 (17.0)	58 (19.0)	71 (23.2)	306	
Age	75.10±7.07[d]	76.96±6.81	77.67±5.80	79.41±7.21[a]	76.9±7.27	<0.001
Comorbidities						
Hypertension	96 (44.7)[d]	38 (17.7)	40 (18.6)	41 (19.1)[a]	215	0.430
Diabetes mellitus	53 (47.3)[d]	20 (17.9)	25 (22.3)[d]	14 (12.5)[ac]	112	0.008
Congestive heart failure	18 (31)[b]	17 (29.3)[a]	10 (17.2)	13 (22.4)	58	0.042
Cancer	8 (26.7)	5 (16.7)	8 (26.7)	9 (30)	30	0.253
Dementia	11 (28.2)	5 (12.8)	9 (23.1)	14 (35.9)	39	0.127
Cerebrovascular event	9 (27.3)	9 (27.3)	7 (21.2)	8 (24.2)	33	0.126
Hypothyroidism	25 (38.5)	14 (21.5)	14 (21.5)	12 (18.5)	65	0.243
Depression	22 (28.9)[c]	15 (19.7)	23 (30.3)[a]	16 (21.1)	76	0.007
CGA						
Katz ADL	5.34±1.48[d]	4.77±2.03	4.90±2.05	4.49±2.02[a]	4.96±1.85	**0.014**
LB-IADL	6.58±2.16[d]	5.77±2.79	6.02±2.71	5.21±3.07[a]	6.02±2.65	**0.005**
MMSE	23.5±5.35[bd]	21.40±6.45	22.31±6.74[d]	18.93±8.40[ac]	21.82±6.98	**<0.001**
MNA-SF	12.13±1.66[d]	11.87±1.63[d]	11.56±2.2[d]	10.29±3.19[abc]	11.5±2.31	**<0.001**
GDS	3.92±3.85	5.90±7.41	6.04±2.85	4.07±3.57	4.67±3.21	0.163
4 m walking speed (m/sn)	0.6±0.26	0.47±0.27	0.70±0.38	0.51±0.40	0.58±0.51	0.114
Handgrip strength (kg)	20.77±7.9[d]	17.9±18.17[d]	17.61±7.16[d]	13.6±6.46[abc]	18.05±8.03	**<0.001**
Clinical frailty score	4.04±1.54[cd]	4.57±1.58	4.74±1.43[a]	4.90±1.50[a]	4.46±1.55	**0.001**
Mortality	23 (31.5)[d]	12 (16.5)	11 (15.1)	27 (37.0)[a]	73	**0.014**
Laboratory values						
Fasting blood glucose (mg/dL)	105.12 (57-345)[d]	96.50 (79-200)	97.34 (69-197)	96.12 (77-196)[a]	98.56 (51-442)	**0.013**
Calculated glomerular filtration rate (mL/min/1.73 m²)	75 (21-90)[d]	76 (25-90)[d]	69 (22-89)	67 (52-90)[ab]	70.5 (60-134)	**<0.001**
Calcium (mg/dL)	9.7 (8.90-10.6)	9.6 (9.10-10.30)	9.6 (8.30-10.9)	9.80 (8.90-11.70)	9.5 (8.2-11.7)	0.097
Total protein (g)/L	7.40 (6.30-8.20)	7.30 (6.40-8.10)	6.91 (5.56-7.84)	7.32 (6.40-8.10)	7.15 (5.2-8.2)	0.672
Albumin (g/L)	4.20 (3.40-4.80)	4.20 (3.60-4.60)	4.10 (2.50-4.80)	4.09 (2.90-4.90)	4.00 (1.80-4.90)	0.774
Leukocyte (WBC) (x10⁹/L)	7.03 (2.63-12.75)	7.09 (3.76-9.69)	6.54 (3.66-11.77)	6.16 (4.14-12.47)	6.77 (2.66-35.77)	0.060
Hemoglobin (Hb) (g/dL)	13.7 (9.10-17.20)	13.55 (7.00-16.60)	13.90 (9.30-15.10)	12.9 (11.00-16.50)	12.60 (7.00-17.70)	0.129
Vitamin B12 (pg/mL)	298 (77-1500)	343 (169-648)	501 (102-1500)	395 (50-1500)	332 (50-1500)	0.132
TSH (µIU/mL)	1.70 (0.02-6.57)	1.52 (0.55-30.59)	2.06 (0.60-1.62)	1.15 (0.02-6.76)	1.48 (0.01-40.72)	0.461
CRP (mg/L)	3.67 (0.20-17.60)	2.70 (0.90-16.60)	4.90 (0.10-79.30)	2.20 (0.10-77.30)	4.80 (0.10-147.12)	0.998
25-hydroxy vitamin D (µg/L)	19.1 (5.7-65.2)	21.6 (5.2-33.3)	19.9 (4.9-47.4)	21.4 (5.3-51.4)	18.2 (4.50-75.2)	0.562

Bold values are p<0.05 and are statistically significant. -value *: Comparison between groups; p-value, [abcd]: Intragroup post hoc value (Bonferroni post hoc tests) [a]: Significant difference to non-sarcopenic non-osteoporotic, [b]: Significant difference to OP, [c]: Significant difference to SP, [d]: Significant difference to OSP, OP: Only osteoporosis group, SP: Only sarcopenic group, OSP: Osteosarcopenic group, CGA: Comprehensive geriatric assesment, Katz ADL: Katz index of activities of daily living, LB-IADL: Lawton-Brody instrumental activities of daily living scale, MMSE: Mini-mental state exam, MNA-SF: Mini-nutritional assessment-short-form, GDS: Geriatric depression scale, CRP: C-reactive protein, WBC: White blood cell

(37%, p=0.014). The comparison of patient comorbidities, comprehensive geriatric assessment tests and laboratory tests are summarized in Table 1.

Logistic regression analysis was performed to determine the factors that may affect osteoporosis, sarcopenia and OSP. Factors that were significant in Table 1 between groups were analyzed further. Adjusted for age and gender, it was determined that diabetes mellitus increases the risk of osteoporosis and OSP. It was observed that the presence of type 2 diabetes mellitus (T2DM) increased the risk of OSP by 2.7 times. No such relationship was found for sarcopenia. Variables that were significant in the previous comparison and were previously known to contribute to the formation of sarcopenia, obesity, and sarcopenic obesity were included in the multiple analysis in the logistic regression analysis. Each group was studied separately to determine the variable that could increase the risk in all three groups. In the osteoporosis and OSP group, diabetes mellitus was found to be a risk-increasing factor. These findings are summarized in Table 2.

Discussion

In our study, OSP patients (prevalence was 23.2%) showed a significant reduction in Katz (ADL), Lawton-Brody (IADL), MMSE and MNA scores for components of comprehensive geriatric assesment. Furthermore, the Clinical Frailty Score was higher in the OSP group, indicating a high frailty rate. Supported by all these scores, the OSP group was at greater risk of physical and cognitive dependence in daily functions than the osteoporotic and sarcopenic groups alone. In addition, the mortality rate was significantly higher in the OSP group compared to the only osteoporosis (OP) and only sarcopenic (SP) groups. Adjusted for age and gender, it was determined that diabetes mellitus increases the risk of osteoporosis and OSP.

Table 2. Logistic regression shows the odds ratio for osteoporosis, sarcopenia and osteosarcopenia

Odds ratio for osteoporosis			
	Odds ratio	**(95% CI)**	**p**
Age	1.047	(1.011-1.084)	**0.001***
Sex (female)	0.826	(0.492-1.388)	0.471
Diabetes mellitus	1.785	(1.071-2.974)	**0.025***
Congestive heart failure	1.564	(0.835-2.931)	0.162
Depression	0.958	(0.544-1.685)	0.881
Odds ratio for sarcopenia			
	Odds ratio	**(95%)**	**p**
Age	1.066	(1.029-1.105)	**<0.001***
Sex (female)	0.537	(0.315-0.916)	**0.022***
Diabetes mellitus	0.618	(0.369-1.034)	0.067
Congestive heart failure	0.709	(0.366-1.374)	0.059
Depression	1.668	(0.951-2.926)	0.074
Odds ratio for osteosarcopenia			
	Odds ratio	**(95%)**	**p**
Age	1.078	(1.033-1.124)	**0.001***
Sex (female)	2.235	(1.140-4.383)	**0.019***
Diabetes mellitus	2.701	(1.366-5.344)	**0.004***
Congestive heart failure	1.308	(0.590-2.878)	0.059
Depression	1.245	(0.628-2.471)	0.530

Bold values indicate signifcant p-value, CI: Confidence interval

The prevalence of OSP in our study was similar to that of other studies (5,25-28). The mean age was significantly higher in the OSP group. There are many reasons for OSP, OP and SP formation. However, as emphasized in previous studies (5,29), the higher mean age in the OSP group suggests that there may be a chronological relationship. When the nutritional status of patients was examined, in many studies poor nutritional status was associated with low MNA score and BMI (5,28). In our study, the MNA score was found to be low in the OSP group.

Many of the previous studies have been specifically focused on physical performance (27,30). Drey et al. (26) showed that some parameters, especially indicative of muscle strength (such as hand grip strength and chair rise time), decreased in the OSP group and they found that balance and coordination tests (such as walking speed) did not affect the OSP group (27). Similarly, Yoshimura et al. (31) reported that hand grip strength and walking speed used in the diagnosis of frailty and sarcopenia was not a risk factor for osteoporosis. In another study, it was found that physical performance and balance were more impaired in those with OSP compared to the non-OSP group (32). In our study, hand grip strength was significantly different between the groups. Although the 4 m walking test was one of the criterias for sarcopenia, it was not statistically significant between the groups. Further studies of coordination, balance and power [and as Yoshimura et al. (31) stated, with many years of follow-up] can give us more insight into this issue.

When muscles and bones are involved, physical performance and risk of fracture come to mind. Cognitive functions and OSP have not been widely studied in literature. However, there are studies showing that muscle and bone health affect cognitive health (33,34). It is difficult to involve dementia patients with very low cognition in studies related to this type of force and to perform tests. However, involving patients who are able to perform the tests, who do not have dementia or who are under follow-up, will make the studies more valuable. There are studies examining the relationship between sarcopenia and cognition. They have shown that low physical performance can lead to low mental performance (35). In our study, MMSE scores of the OSP group were lower than the other groups. However, there was no difference between the groups in terms of dementia rates. In other words, the decrease in MMSE scores were significant but the dementia rate was not. In a study of OSP obesity, cognitive

decline of patients was examined and no significant relationship was found between the two groups (36). It is an expected and demonstrated condition that the physical performance of patients with cognitive decline (but not dementia) is affected. There are studies showing that cognitive status is affected in both osteoporosis and in sarcopenia and with treatments (33,35,37,38). The main hypothesis of these studies summarizes that "Interventions to prevent sarcopenia and osteoporosis and increase bone-muscle strength can also help the cognitive dimension of functionality in the elderly community". Specific prospective studies will be valuable for OSP cases.

When we look at the relationship between comorbidities of patients and OSP, interestingly, in our study the percentage of chronic diseases such as HT, T2DM and CHF was higher in the non-sarcopenic non-osteoporotic group. When a similar study was examined, especially gout, osteoarthritis and other inflammatory diseases were found to be risk factors for OSP (5). One of the main reasons for this may be that people with a chronic illness come for periodic exams because of their illness. Thus, they enter screening programs for osteoporosis and malnutrition and can be diagnosed and treated before their disease progresses.

In the logistic analysis performed in our study, it was found that the presence of T2DM increases the risk of OSP. Even though incidences of chronic diseases such as T2DM and HT was higher in the non-sarcopenic non-osteoporotic group, it was found that the risk of OSP increased 2.7 times in those with T2DM in logistic regression. Diabetes mellius is considered among the secondary causes of OSP (39,40). T2DM is characterized by insulin resistance, inflammation, advanced glycation end product accumulation and increased oxidative stress. These properties can negatively affect various aspects of muscle health, including muscle mass, strength, quality, and function, by leading to disruptions in protein metabolism, vascular and mitochondrial dysfunction, and cell death (40). In the analysis in our study, while risk increased in the osteoporosis and OSP groups, the high OR in the OSP group draws attention.

In this study, glucose and GFR values were significantly lower in the OSP group. In many studies on OSP, GFR related to muscle structure was found to be low, as expected. Glucose may be related to the nutritional status of the patients. Considering that the percentage of T2DM was low in the OSP group, it would not be meaningful to evaluate this result as a treatment complication. It may be reasonable to detect low glucose levels in this group with poor nutrition and low MNA score. Contrary to expectations, the ratio of albumin and total protein used as other nutrient markers, did not differ between the groups. In our study, the vitamin D level, which is implicated in the pathophysiology of sarcopenia and osteoporosis, was found to be insignificant. In some studies in literature, low vitamin D was found to be associated with OSP. In other studies, (as in our study) no relationship was found between them. This heterogeneity was indicated in a review and larger studies have been recommended (41).

In a study of 1.083 patients followed for 4 years to investigate the relationship between OSP and frailty, it was found that OSP caused more frailty than OP alone or SP alone (31). In another study, OSP obesity and frailty were examined and a significant correlation was found with all three tests [frailty phenotype (Fried criteria), gerontopole frailty screening tool and the FRAIL scale]. The weaknesses of this study were that it included people younger than 65 years old and it was done with just women. In another study conducted in our country, the frailty score determined by Fried criteria was found to be high in the OSP group (42). Another study provided information about the relationship between individual OS, SP and OSP groups and frailty. The presence of OS and OSP increased the risk of frailty, but was not associated with SP. They reported that OSP had more frailty than OS and SP alone (31). In our study, the mean clinical frailty score was found to be high in the OSP group, consistent with frailty.

OSP is a condition that increases the morbidity affecting elderly people. Mortality was found to be correlated with OSP, as expected. In the study performed by Balogun et al. (6) 10-year mortality was found to be higher in the OSP group compared to the SP group alone and the OP group alone. The lower mortality rates of the alone groups indicate that the combination of these conditions increases mortality. In a study of 314 patients with hip fractures, 1-year mortality was found to be 15.1%. This was higher than the individual OP and SP groups (7). In another study, poor musculoskeletal health was found to increase the risk of death regardless of age (43). In another study conducted with a good number of patient populations, when all three groups were compared, similar to our study, after a Cox regression analysis, OSP individuals had a 2.48-fold risk of death. Also in this study, falls, fractures, and functional impairments were found more frequently in OSP patients. In our study, patient mortality was determined retrospectively and 37% of the patients in the OSP group died. This rate was higher than the other groups. In this study, causes of death were not considered as subgroups.

Treatment of OSP is as important as its screening and definition. Studies have found that adequate amounts of protein (1.2-1.5 g/kg/day), vitamin D (800 IU/day) and calcium (1.000-1.200 mg/day) supplements can be tolerated. It has been shown that some components such as lean mass, bone density and fracture risk can be alleviated with these supports (4).

Study Limitations

There are limitations to our study. First, this was a retrospective cross-sectional study that did not allow the establishment of

chronological or causal relationships leading to OSP. Second, a score such as the more commonly used Fried score could have been used instead of the clinical frailty score used to define frailty. In further studies, it may be planned to use more objective methods with frailty score and mortality status as sub-groups.

Strengths of our study: This study presents data from a geriatric clinic that gives the clinician insight into the prevalence, degree of overlap and the geriatric functions affected by the two major pathologies of the locomotor and skeletal system. It is a study that gives information about OSP in our country from the whole geriatric society. It is also the first data in our country with both frailty and mortality related to OSP. In our study, the diagnosis of sarcopenia was done by BIA and according to revised EWOGS2 criteria. Osteoporosis was diagnosed using femoral neck or total in accordance with WHO standards.

Conclusion

In our study we showed that OSP, which is the most serious and last stage of bone and muscle loss combination, is closely related to physical and cognitive dependence, frailty and death, which are the most feared conditions in older adults. Osteoporosis and sarcopenia should be screened together, preventive measures should be taken before they become serious, and treatments such as osteoporosis treatment, exercise and nutrition therapy should be given and followed.

Ethics

Ethics Committee Approval: Approval for the study was obtained from the Ethics Committee of Ankara University Faculty of Medicine with document number: 10-806-19.

Informed Consent: Written informed consent was obtained from the patients.

Peer-review: Externally peer-reviewed.

Authorship Contributions

Surgical and Medical Practices: H.S.Ö., R.B., T.T., D.M.S., Ç.C., V.A., A.Y., Concept: S.A., M.V., Design: S.A., M.V., Data Collection or Processing: H.S.Ö., R.B., T.T., D.M.S., Ç.C., V.A., A.Y., Analysis or Interpretation: H.S.Ö., R.B., S.A., Literature Search: H.S.Ö., D.M.S., Ç.C., V.A., A.Y., Writing: H.S.Ö., M.V.

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