



The role of osteosarcopenia and balance in predicting fall risk in the elderly

Yaşlıda düşme riskini tahmin etmede osteosarkopeni ve dengenin rolü

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ABSTRACT

Aim: The objective of this study was to investigate the role of balance and osteosarcopenia in the estimation of fall risk in the elderly admitted to the geriatrics outpatient clinic.

Methods: Patients admitted to the outpatient geriatric clinic were included in the study. The bone mineral density of 205 participants included in the study was evaluated by dual-energy X-ray absorptiometry (DXA), muscle mass bioimpedance analysis (BIA), Tinetti balance, and gait assessment (TBGA), balance and gait. Osteosarcopenia was defined as sarcopenia plus osteoporosis/osteopenia. Patients were divided into 4 groups according to BIA and DXA data.

Results: Osteosarcopenia was detected in 27 (13.2%) of all participants. In addition, while the number of falls was higher in the osteosarcopenia group than in the other groups, the calf circumference, ECC, and TBGA scores were significant. According to the TBGA score, the risk of falling was found to be high in one of every three patients. TBGA scores ($p<0.001$, OR=1.912 [1.596-2.291]) and calf circumference ($p=0.013$, OR=1.159 [1.032-1.301]) were found to be independent variables in the development of falls.

Conclusion: In this study, it was found that osteoporosis/osteopenia and sarcopenia were common in elderly patients, while balance, handgrip strength, calf circumference, and age were predictors of falling. Considering that with the aging global population, both sarcopenia and osteoporosis will become more common and therefore an increase in falls, our findings have shown that the parameters determined in the follow-up and treatment of elderly patients can be easily used in the early detection of fall risk.

Keywords: balance; elderly; fall; osteosarcopenia

ÖZET

Amaç: Çalışmamızda geriatri polikliniğine başvuran yaşlılarda düşme riskinin tahmin edilmesinde denge ve osteosarkopeni varlığının rolünü araştırmayı amaçlanmaktadır.

Yöntem: Çalışmaya dâhil edilen 205 katılımcının kemik mineral yoğunluğu çift enerjili X-ray absorpsiyometri (DXA) ile kas kütlesi bioempedans analizi (BIA) ile denge ve yürüme Tinetti denge ve yürüyüş değerlendirmesi (TDYD) ile değerlendirildi. Hastalar BIA ve DXA verilerine göre 4 gruba ayrılmıştır.

Bulgular: Tüm katılımcıların 27'sinde (%13.2) osteosarkopeni saptandı. Osteosarkopeni grubunda diğer gruplara göre düşme sayısı daha yüksek iken baldır çevresi, EKK ve TDYD skorları anlamlı düzeyde düşüktü. TDYD skoruna göre her üç hastadan birinde düşme riski yüksek saptandı. Düşme gelişmesinde TDYD skoru ($p<0.001$, OR=1.912 [1.596-2.291]) ve baldır çevresi ($p=0.013$, OR=1.159 [1.032-1.301]) bağımsız değişkenler olarak bulundu.

Sonuçlar: Bu çalışmada, yaşlı hastalarda, osteoporoz/osteopeni ve sarkopeninin yaygın olduğu, denge, el kavram kuvveti, baldır çevresi ve yaşın düşmeyi belirleyen prediktörler olduğu bulundu. Yaşlanan küresel nüfusla birlikte hem sarkopeni hem de osteoporozun daha yaygın hale geleceği ve dolayısıyla düşmesinde artış göstereceği düşünüldüğünde, bulgularımız, yaşlı hastaların takip ve tedavisinde belirlenen parametrelerin düşme riskinin erken tanınmasında kolaylıkla kullanılabileceğini göstermiştir.

Anahtar kelimeler: denge; yaşlı; düşme; osteosarkopeni

Introduction

Falling is defined as the immobility of the individual at a level lower than the current level without any compelling force, stroke or syncope (Gibson, 1987). One out of every three elderly people aged 65 and over living in the community experiences a fall at least once a year (Curcio, Gomez & Reyes-Ortiz, 2009). This rate also increases with advancing age (Fuller, 2000). The elderly often experience falls because of a medical problem or modifiable risk factors. The most common risk factors for falls are balance and gait disturbances, medications (eg, sedatives and anti-psychotics), medical conditions such as Parkinson's disease and cerebrovascular accident, joint disorders, poor vision (often cataract-related), environmental causes, and inappropriate footwear (Rao, 2005). Tinetti balance and gait assessment

(TBGA), also known as performance-oriented mobility assessment (POMA), which is a screening method that can be easily used especially in patients who present to outpatient clinics, enables the detection of patients at risk of falling (Köpke & Meyer, 2006).

Sarcopenia, which occurs with advancing age, is a geriatric syndrome that occurs with loss of muscle mass and muscle strength associated with nutritional disorders, additional chronic diseases, decreased physical activity or impaired mobility (Cruz-Jenotf et al., 2019). In the consensus of the European Working Group on Sarcopenia in Older People (EWGSOP) revised in 2018, it was recommended to use markers of decreased muscle mass and poor physical performance in the diagnosis of sarcopenia (Cruz-Jenotf et al., 2019).

Osteosarcopenia (OSP) has been defined as a new geriatric syndrome in which osteoporosis/osteopenia and sarcopenia coexist (Hassan & Duque, 2017; Huo et al., 2015). There is a decrease in both bone and muscle mass associated with aging and a decrease in physical performance. Growth hormone/insulin-like growth factor-1 (GH/IGF1) and gonadal sex hormones play a key role in the development of OSP (Girgis, Mokbel & Digirolamo, 2014). Compared with sarcopenia and osteoporosis/osteopenia separately, OSP causes higher rates of falls, fractures, and disability in the elderly (Drey et al., 2016). In cross-sectional studies, it has been shown that OSP is associated with decreased physical performance, increased bone turnover and fragility, and low trauma fracture development (Frisoli, Chaves, Ingham & Fried, 2011; Drey et al., 2016).

Although the negative effects such as falls and subsequent clinical pathologies, increase in treatment costs, addiction and deterioration in quality of life in the elderly are known, the relationships between OSP, balance, walking and muscle strength are still not fully understood. Therefore, in this study, it was aimed to investigate the role of balance and the presence of osteosarcopenia in the estimation of fall risk in a group of elderly patients admitted to the outpatient unit.

Methods

This retrospective, cross-sectional study was conducted on patients aged 65 and over who applied to the Internal Medicine and Geriatrics outpatient clinic between August 2021 and March 2022 and were able to complete the questionnaires and measurements. Anthropometric measurements (calf circumference (CC), height, weight), clinical and laboratory data of the patients were obtained from medical files. Body mass index (BMI) was calculated using the formula body weight/height² (kilogram/meter²). Active psychiatric illness (major depression, psychotic episode) with a diagnosis of dementia, with communication barriers such as hearing loss, speech disorder, confusion, mental retardation, general condition disorder (such as severe pain, critical shortness of

breath, consciousness change, medical emergency), bipolar disorder) were excluded from the study.

Evaluation of osteopenia/osteoporosis, sarcopenia and osteosarcopenia

Bone mineral density (BMD) was measured by double X-ray absorptiometry (DXA). Osteopenia was defined as a BMD (T-score) of -1.0 to -2.5 in standard deviations (SD) for a young, healthy adult, and osteoporosis as a BMD of -2.5 SD or less. Bioimpedance analysis (BIA) was used to measure sarcopenia. The skeletal muscle mass index threshold values, which were performed by Bahat et al. (2016) in Turkey, were classified based on 9.2 kg / m² and 7.4 kg / m² values in men and women, respectively.

Muscle strength was evaluated with hand grip strength (HGS). In this study, Jamar (hydraulic) dynamometer was used for HGS measurement. HGS measurement results were evaluated according to the muscle strength reference threshold values (22 kg for women and 32 kg for men) made in Turkey by Bahat et al. (2016).

Evaluation of balance and gait

Tinetti balance and gait assessment (TBGA) was used to evaluate gait and balance. According to the test results, if the total score is ≤18, it indicates high fall risk, 19-23 points indicates moderate fall risk, and ≥24 indicates low fall risk (Köpke & Meyer, 2006). In addition, the fall history of the patients and the number of falls developed in the last year were also recorded.

Statistical analysis

All statistical analyzes were performed using SPSS 26. Variables were analyzed for normality of distribution with Kolmogorov–Smirnov and Shapiro–Wilk tests. G-POWER analysis was used to calculate sample size. Accordingly, the minimum sample size to evaluate the primary endpoint of the study was 140, assuming a power of 80% and a bilateral alpha level of 0.05.

Table 1. Demographic and clinical characteristics of the participants

		Groups				p value
		NONS (n=118)	OP (n=41)	SP (n=19)	OSP (n=27)	
Age		73.11±6.71	74.24±5.79	72.00±6.97	76.67±9.60	0.044*
Sex	Male	74 (%63.8)	8 (%6.9)	17 (%14.7)	17 (%14.7)	0.015*
	Female	44 (%49.4)	33 (%37.1)	2 (%2.2)	10 (%11.2)	
Smoking	No	107 (%58.5)	37 (%20.2)	14 (%7.7)	25 (%13.7)	0.145
Alcohol	No	118 (%57.6)	41 (%20.0)	19 (%9.3)	27 (%13.2)	0.495
BMI		25.38±4.21	25.59±5.88	22.24±5.08	22.69±6.37	0.069
Comorbidities	CC	29.42±3.49	29.63±4.77	28.33±4.40	25.41±4.64*	0.001*
	DM	31 (%60.8)	5 (%9.8)	5 (%9.8)	14 (%19.6)	
	HT	37 (%59.7)	13 (%21.0)	1 (%1.6)	16 (%17.7)	
	CVD	5 (%50.0)	1 (%10.0)	2 (%20.0)	12 (%20.09)	0.006*
	Others	45 (%54.9)	22 (%26.8)	11 (%13.49)	14 (%4.9)	
Number of falls		1.08±.90	1.10±1.20	1.05±.85	2.04±.65*	<0.001*
HGS		19.15±6.40	19.40±4.58	17.96±5.29*	11.59±6.20*	<0.001*
TBGA		22.40±3.86	21.76±4.46	20.53±4.62	16.70±3.33*	<0.001*

NONS: normal group; OP: Osteopenia/osteoporosis; SP: Sarcopenia; OSP: Osteosarcopenia; BMI: Body Mass Index; CC: Calf Circumference; DM: Diabetes mellitus; HT: Hypertension; CVD: Cardiovascular Disease; HGS: Hand Grip Strength; TBGA: Tinetti Balance and gait assessment

*p<0.05

Table 2. Correlation analysis between number of falls, age, TBGA, HGS, calf circumference

		Falls	Age	HGS	TBGA	CC
Falls	r	1	0.192**	-0.290**	-0.656**	-0.259**
	p		0.006	0.000	0.000	0.000
Age	r	.192**	1	-0.182**	-0.268**	-0.178*
	p	.006		0.009	0.000	0.011
HGS	r	-.290**	-.182**	1	0.410**	0.432**
	p	.000	.009		0.000	0.000
TBGA	r	-.656**	-.268**	.410**	1	0.237**
	p	.000	.000	.000		0.001
CC	r	-.259**	-.178*	.432**	.237**	1
	p	.000	.011	.000	.001	

TBGA: Tinetti Balance and gait assessment; HGS: Hand Grip Strength; CC: Calf Circumference

*p<0.05, **p<0.001

Descriptive statistics were given for continuous variables. Continuous variables of the groups were evaluated using independent samples t-test and analysis of variance (ANOVA). Relationships between parameters were investigated by chi-square test and Pearson correlation analysis. Logistic regression analysis was used to determine the factors affecting falling. Statistical significance level was determined as $p < 0.05$.

Patients were divided into 4 groups according to BIA and DXA data, and analyzes were performed between these groups.

Group 1: normal group (without osteoporosis/osteopenia and sarcopenia, NONS)

Group 2: only osteoporosis/osteopenia but no sarcopenia (OP)

Group 3: those with sarcopenia but no osteoporosis/osteopenia (SP)

Group 4: It was defined as those with both osteoporosis/osteopenia and sarcopenia (osteosarcopenic group, OSP) (Drey et al., 2016).

Ethical aspect of research

The study was conducted in accordance with the Declaration of Helsinki. The study protocol was approved by the İnönü University Non-Invasive Ethics Committee (Number: 2022/3370).

Results

The mean age of the 205 participants included in the study was 73.7 ± 7.1 years, and 43.4% (74.22 ± 6.8) were women. Participants were divided into four groups based on their BMD and BIA results. Accordingly, 27 (13.2%) of the participants were grouped as OSP, 19 (9.2%) as SP, 41 (20%) as OP and 118 (57.5%) as NONS. The mean age of the OSP group was significantly higher than the other groups ($p=0.044$). In addition, while the number of falls was higher in the OSP group compared to the other groups, the CC, HGS and TBGA scores were significantly lower. Table 1 shows the demographic evaluation results of the patients and the number of falls.

When classification was made according to low, medium and high fall risk according to TBGA, 63 (30.7%) of the participants had a moderate fall risk and 59 (28.8%) had a high fall risk. In patients with high fall risk according to TBGA, the number of falls was significantly higher in the last year compared to low and medium risk groups ($p < 0.001$, $p = 0.001$;

respectively). 18 (66.6%) of osteosarcopenic patients had a high risk of falling and 9 (33.4%) had a moderate risk of falling.

When falling at least once a year was evaluated among the diagnostic groups, while all 27 patients in the OSP group had a fall history, 13 (68.4%) patients in the SP group, 20 (48.8%) patients in the OP group, and 36 (30.5%) patients in the NONS group ($p < 0.001$).

In the correlation analysis between the number of falls and age, TBGA score and HGS, the number of falls showed a positive correlation with age, and a negative correlation between TBGA score, HGS and CC (Table 2).

Logistic regression analysis was performed to determine the parameters affecting the risk of falls in the participants. TBGA score ($p < 0.001$, OR=1.912 [1.596-2.291]) and calf circumference ($p = 0.013$, OR=1.159 [1.032-1.301]) were found to be independent variables in the development of falls. In our study, age and HGS were found to be ineffective in determining the risk of falls (Table 3).

Discussion

Osteosarcopenia, which is characterized by the coexistence of osteoporosis/osteopenia and sarcopenia, is one of the geriatric syndromes that create a global health burden. In our study, it was found that the number of falls in osteosarcopenic patients was higher than the other patients, and their TBGA scores and HGS were significantly lower. Moreover, all of these patients had a history of falls within the last year. According to the correlation analysis, falls increased with age. In addition, there was a negative correlation between hand grip strength and balance test scores and falls. We found that TBGA scores and CC are independent risk factors for the development of falls in our patients. These data confirmed that there is a significant relationship between the presence of osteoporosis and sarcopenia and balance in the basis of frequent falls in the elderly. Therefore, the application of balance tests as well as osteoporosis and sarcopenia screenings in the outpatient follow-up of elderly patients may provide significant benefits. In this study, osteoporosis was higher in women, sarcopenia was higher in men, and osteosarcopenia was equal in both genders.

Table 3. Results of logistic regression analysis of independent variables for falls

	Falls	
	p*	OR [95% CI]
Age	0.259	1.047 [0.967-1.133]
Sex	0.965	0.978 [0.358-2.670]
HGS	0.982	0.999 [0.920-1.085]
TBGA	<0.001	1.912 [1.596-2.291]
Calf circumference	0.013	1.159 [1.032-1.301]

HGS: Hand Grip Strength; TBGA: Tinetti Balance and gait assessment; CI: confidence interval; OR: odds ratio

*p < 0.05 according to multivariate binary logistic regression analysis.

However, there was no difference between the sexes in terms of falls. Although this result supports studies showing that hormonal and biological differences between the sexes play a role in the development of these diseases with bone and muscle loss, it was important in terms of showing that falling is a situation independent of gender.

Sarcopenia is a skeletal muscle disease characterized by loss of muscle mass and strength, and is associated with adverse outcomes such as fractures, falls, fragility, increased morbidity and mortality (Cruz-Jentoft & Sayer, 2019). Osteoporosis/osteopenia is characterized by low bone mass and mineral density as well as deterioration of bone-tissue microarchitecture. Osteoporosis causes an increase in bone fragility, predisposing to fracture, disability and death (Compston, McClung & Leslie, 2019; Nielsen, Abdulla, Andersen, Schwarz & Suetta, 2018). Bone and muscle tissue are closely related organs, and there are multiple communication channels between both tissues via both mechanical and chemical pathways (Hirschfeld, Kinsella & Duque, 2017). These mechanisms are known to be effective on bone and muscle tissue such as osteocalcin, IGF1, osteoglycin, osteonectin, Interleukin-6, and myostatin. (Hirschfeld et al., 2017). However, the evidence for the pathophysiological basis of the development of OSP, which occurs with the joint interaction of bone and muscle tissue, is still at the experimental level (Salech et al., 2021). Although the etiology is not clearly revealed, the identification of the coexistence of these two pathologies may provide clinicians with convenience in diagnosis and treatment. Co-evaluation of elderly or at-risk adults for osteoporosis/osteopenia and sarcopenia may increase therapeutic response due to joint interventions (resistance exercises, nutritional support, vitamin D and calcium supplementation).

In our study, the prevalence of OSP was found to be 13.2%. In another study conducted in our country, the prevalence of OSP was found to be 23.2% (Öztorun et al., 2022). In studies conducted with hospitalized patients with a history of hip fracture or fall, the prevalence of OSP has been reported to reach 58%. (Huo et al., 2015; Di Monaco, Vallero, Di Monaco & Tappero, 2011). These differences between studies may have varied depending on the population from which participants were selected and the methods used. However, although the rate seems low, it is a remarkable result when it is considered that it can cause higher rates of falls, disability and even death, compared to both osteoporosis and sarcopenia.

Studies investigating the relationship between CC and falls have presented different results in the literature (Lusardi et al., 2017). In the study of Díaz-Villegas et al. (2016) a high risk of

falls was found in the group with a calf circumference of <31 cm, in addition, low CC was shown to be an independent risk factor for falls development. In another study, although no significant relationship was found between falls and CC, it was emphasized that measurement of calf circumference should be a part of falls risk and nutritional assessments in elderly populations (Soares SRM, Soares AB & de Sá, 2013). In our study, CC was found to be one of the independent risk factors associated with falls. Simultaneous evaluation of CC with balance tests seems to increase the probability of predicting a falls.

There are limited data on whether the HGS used in the assessment of sarcopenia is a predictor of falls. In the study of Flecher, (2019) it was stated that HGS predicted falls at a lower level compared to the lower extremity muscle group assessment. This situation is explained as HGS is not directly related to balance (Fletcher, 2019). According to Gafner et al. (2020) determined that hip muscle strength was superior to HGS in determining the risk of falling. On the contrary, Bohannon (2019) advocate the use of HGS as a biomarker associated with upper extremity muscle strength, bone mineral density, and other geriatric syndromes, including falls. Our study supported the work of Bohannon (2019). In our study, HGS was lower in OSP and SP groups, and the number of falls increased as HGS decreased. Therefore, HGS can be used as a component of rapid and practical assessment in identifying older adults at risk of falls.

There are numerous studies showing that osteosarcopenia is associated with falling, worse physical performance and balance in community-dwelling older adults (Balogun et al., 2019; Salech et al., 2021; Sepúlveda-Loyola et al., 2020; Teng et al., 2021). A study conducted with 680 elderly individuals who applied to hospital in Australia found the frequency of OSP to be 47.4%. Additionally, in this study, it was stated that osteosarcopenic elderly people are at high risk of falls and fractures (Huo et al, 2015). In the review of Teng et al. (2021) it was shown that osteosarcopenia significantly increases the risk of falls. In another study evaluating the development of falls in community-dwelling older adults in Chile, it was shown that the prevalence of OSP increases with age, and falls and fractures develop more frequently in these patients (Salech et al., 2021). In our study, we found that all of the OSP patients developed falls within the last year, and two out of every three patients had a high risk of falling, in line with the literature. In addition, the rate of falling was 68.4% in only those with sarcopenia, it was 48.8% in the osteoporosis group, and this rate was 100% in the osteosarcopenic group. Although this is a predictable result, it is necessary to consider the association of sarcopenia and osteoporosis/osteopenia, to prevent fall-related complications, and to diagnose both pathologies in the early period and to start treatment immediately in order to reduce treatment costs.

Many risk factors associated with the risk of falling have been identified in studies (Zou et al., 2019). The most prominent and consistent risk factor for falls is balance disorder (Gale, Cooper & Aihie Sayer, 2016; Hunter & Speechley, 2020). The most commonly used tests for determining balance and fall risk with older adults are the Berg Balance Scale (BDS), Timed "Get Up and Walk" Test (TUG), Functional Reach Test (FRT), and Tinetti balance and gait assessment (TBGA). Among these tests, TBGA is valuable as it evaluates functional stability limits, expected postural control and single-

extremity static stability together (Sibley, Beauchamp, Van Ooteghem, Straus & Jaglal, 2015). Recent studies suggest the use of TBGA in the investigation of balance and fall risk in healthy older adults living in the community (Rosa, Perracini & Ricci, 2019; Jahantabi-Nejad & Azad, 2019). TDYT test was used.

On the other hand, the threshold values used for the definition of fall risk in clinical balance tests are contradictory. However, the recommended cut-off value to determine the risk of falling TBGA is 24 and below. Accordingly, our analyzes showed that one out of every three patients had a high risk of falling and one third had a moderate risk of falling. Moreover, TBGA scores were determined as an independent risk factor in the prediction of falls. For this reason, the evaluation of the balance test of each elderly patient who applied to the outpatient clinic at each visit will provide important benefits such as prevention of falls.

There are some limitations of our study. The first and most important of these is that our study was planned as cross-sectional. Another limitation of ours is that it does not include follow-ups for recurrent falls or fracture development after treatment in patients diagnosed with OSP, CP or OP. Finally, data on the evaluation of physical functions and nutritional status, which are effective in the development of OSP, are not included in our study. Despite its limitations, this study is valuable in terms of developing a perspective on falling, which is one of the most common causes of hospital admissions in the elderly, from the perspective of balance and osteosarcopenia.

Conclusion and Recommendations

In this study, it was found that osteoporosis/osteopenia and sarcopenia were common in elderly patients, while balance, hand grip strength, calf circumference and age were predictors of falls. Considering that with the aging global population, both sarcopenia and osteoporosis will become more common and therefore an increase in falls, our findings have shown that the parameters determined in the follow-up and treatment of elderly patients can be easily used in the early detection of fall risk.

Conflict of interest

There is no conflict of interest.

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Ethics Committee Approval

The study protocol was approved by the İnönü University Non-Invasive Ethics Committee (Number: 2022/3370).

Informed Consent

Informed consent was obtained from all individual participants included in the study.

Peer-review

Externally peer-reviewed.

Author Contributions

F.D.Y.: Literature Search, Design, Concept, Materials, Data Collection and/or Processing, Supervision, Critical Review, Writing Manuscript.

N.C.: Concept, Materials, Data Collection and/or Processing, Writing Manuscript

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