Research, Society and Development, v. 13, n. 12, e08131247547, 2024
(CC BY 4.0) | ISSN 2525-3409 | DOI: http://dx.doi.org/10.33448/rsd-v13i12.47547

Diagnosis and treatment of osteosarcopenia in geriatric patients

Diagnóstico e tratamento da osteossarcopenia em pacientes geriátricos

Diagnóstico y tratamiento de la osteosarcopenia en pacientes geriátricos

Received: 11/15/2024 | Revised: 11/22/2024 | Accepted: 11/23/2024 | Published: 11/26/2024

Putu Phalguna Putra Nugraha[1]
ORCID: https://orcid.org/0009-0009-4691-9032
Internal Medicine Residency Program, Faculty of Medicine, Udayana University, Indonesia
Prof. Dr. I.G.N.G. Ngoerah General Hospital, Indonesia
E-mail: putu.nugraha.pn@gmail.com
Ni Ketut Rai Purnami[2]
ORCID: https://orcid.org/0009-0000-8751-8619
Department of Internal Medicine Faculty of Medicine, Udayana University, Indonesia
Prof. Dr. I.G.N.G. Ngoerah General Hospital, Indonesia
E-mail: raiarimbawakinjora@gmail.com

Abstract
Osteosarcopenia is a musculoskeletal disorder, in which bone mass, microarchitectural of bone, muscle mass, strength, and performance decrease significantly with age. The majority of osteosarcopenia is experienced by the elderly, sedentary population, as well as patients who have comorbidities that affect the musculoskeletal system or interfere with physical activity. This article aims to present a study on osteosarcopenia in geriatric patient. Osteoporosis represents a major health problem contributing to millions of fractures worldwide, whereas sarcopenia is associated with metabolic outcomes and physical decline. Both diseases affect physical and social function, confidence, and the patient's quality of life. Osteosarcopenia is the term when both conditions occur concomitantly. Interactions between both conditions may accelerate individual disease progression, which is associated with higher morbidity from falls, fractures, disability as well as mortality.
Keywords: Osteosarcopenia; Diagnosis; Treatment; Elderly; Older adults.

Resumo
A osteossarcopenia é um distúrbio musculoesquelético, no qual a massa óssea, a microarquitetura óssea, a massa muscular, a força e o desempenho diminuem significativamente com a idade. A maioria dos casos de osteossarcopenia ocorre em idosos, em populações sedentárias, bem como em pacientes com comorbidades que afetam o sistema musculoesquelético ou interferem na atividade física. O objetivo do presente artigo é apresentar um estudo sobre osteosarcopenia em paciente geriátrico. A osteoporose representa um grande problema de saúde, contribuindo para milhões de fraturas em todo o mundo, enquanto a sarcopenia está associada a desfechos metabólicos e declínio físico. Ambas as doenças afetam a função física, social, a confiança e a qualidade de vida dos pacientes. A osteossarcopenia é o termo utilizado quando ambas as condições ocorrem concomitantemente. As interações entre ambas as condições podem acelerar a progressão individual da doença, o que está associado a uma maior morbidade devido a quedas, fraturas, incapacidade, bem como maior mortalidade.
Palavras-chave: Osteossarcopenia; Diagnóstico; Tratamento; Idosos; Adultos mais velhos.

Resumen
La osteosarcopenia es un trastorno musculoesquelético en el que la masa ósea, la microarquitectura ósea, la masa muscular, la fuerza y el rendimiento disminuyen significativamente con la edad. La mayoría de los casos de osteosarcopenia son experimentados por la población anciana y sedentaria, así como por pacientes que tienen comorbilidades que afectan el sistema musculoesquelético o interfieren con la actividad física. El objetivo de este artículo es presentar un estudio sobre la osteosarcopenia en un paciente geriátrico. La osteoporosis representa un problema de salud importante que contribuye a millones de fracturas en todo el mundo, mientras que la sarcopenia está asociada con resultados metabólicos y el deterioro físico. Ambas enfermedades afectan la función física y social, la confianza y la calidad de vida de los pacientes. La osteosarcopenia es el término utilizado cuando ambas condiciones ocurren simultáneamente. Las interacciones entre ambas condiciones pueden acelerar la progresión de la

[1] Internal Medicine Residency Program, Faculty of Medicine, Udayana University/Prof. Dr. I.G.N.G. Ngoerah General Hospital, Indonesia.
[2] Department of Internal Medicine Faculty of Medicine, Udayana University/Prof. Dr. I.G.N.G. Ngoerah General Hospital, Indonesia.

enfermedad individual, lo que se asocia con una mayor morbilidad debido a caídas, fracturas, discapacidad y mortalidad.
Palabras clave: Osteosarcopenia; Diagnóstico; Tratamiento; Ancianos; Adultos mayores.

1. Introduction

Osteosarcopenia is a musculoskeletal disease that consists of osteoporosis and sarcopenia. This condition is commonly found in the elderly population. Osteoporosis is a disease characterized by low bone mass and structural deterioration of bone tissue. It is a chronic metabolic bone disease that is widely prevalent and represents a major global health issue that contributes to 8.9 million fractures worldwide each year. Sarcopenia is a progressive and generalized decline in muscle strength, function, and mass associated with aging or disease. Sarcopenia has been identified as a predictor of high fall risk. Due to its wide and varying definitions adopted in different centers, estimates of sarcopenia's prevalence differ widely across the globe, ranging from 3% to 30%. Osteosarcopenia is associated with higher morbidity from falls, fractures, disability, and mortality. Understanding the overlapping pathophysiology between these two conditions could provide valuable insights into the development of potential therapies for osteosarcopenia (Paintin, Cooper, & Dennison, 2018; Rosenberg, 2011; Johnell & Kanis, 2006; Barnsley et al., 2021; Laskou, Patel, Cooper, & Dennison, 2022)

Individuals with low bone mass generally also have low muscle mass. A study assessing the relationship between total body bone mineral content and lean mass in men and women aged from 2 years to 87 years old found that bone mass is closely and linearly related to muscle mass throughout life. In another study, lean mass was identified as a better predictor of whole-body bone mineral density (BMD) to fat mass and fracture incidence. The Hertfordshire cohort study reported that muscle size and strength are positively associated with bone size and strength. A study conducted in Ecuador, which predominantly involved female subjects, found greater bone mass loss in patients with osteosarcopenia compared to those with osteoporosis. A positive relationship between the decline in muscle and bone mass for one year was observed in older individuals, with an increased risk of fractures and reduced muscle strength being associated with a decrease in vertebral and hip BMD (Edwards et al., 2013; Ferretti et al., 1998; Ilesanmi-Oyelere, Coad, Roy, & Kruger, 2018; Intriago, Maldonado, Guerrero, Messina, & Rios, 2020; Leslie et al., 2020).

The prevalence of osteosarcopenia in the population increases with age and is found to be higher in women compared to men. Estimates of the prevalence of this condition vary widely, ranging from 5% to 37% depending on the population and the definition of sarcopenia used. The highest prevalence rates are observed in patients with fractures. In a study in China involving 316 communities of individuals aged 65 years and older, 10.4% of men and 15.1% of women were found to have osteosarcopenia. A prevalence rate of 37% was reported in a study of 680 elderly communities in Australia with a history of falls. In Italy, research of 313 elderly women who had experienced hip fractures found a sarcopenia prevalence of 58%. BMD values were significantly lower in women with sarcopenia, and adults with sarcopenia were found to have a fourfold higher risk of developing osteoporosis compared to adults without sarcopenia. Studies suggest that when an individual is diagnosed with sarcopenia, it is associated with a high risk of developing osteoporosis, and vice versa (Laskou et al., 2022).

Awareness of the complex relationship between muscle and bone can initiate the development of diagnostic pathways for osteosarcopenia and the identification of osteoporosis and sarcopenia. In clinical practice, patients who experience falls, fractures, slower gait, difficulty rising from a seated position, weight loss, low body mass index (BMI), or signs of muscle wasting should undergo further evaluation on the diagnosis of osteoporosis and sarcopenia. Simple tools are available to assist clinicians in identifying sarcopenia and osteoporosis separately (Laskou et al., 2022). Several modalities and screening tools can be used to evaluate patients with sarcopenia, ranging from screening questionnaires to radiographic imaging to assess cross-sectional muscle area (CSA). A sarcopenia working group in Europe, the European Working Group on Sarcopenia in

Older People 2 (EWGSOP2), proposed an algorithm called Find-Assess-Confirm-Severity (FACS) for detecting cases of sarcopenia (Ardelian & Hurezeanu, 2022). The FRAX score is a validated and widely used tool for osteoporosis risk stratification, enabling decisions regarding therapy initiation for postmenopausal women and men aged 50 and older having fracture risk factors (Laskou et al., 1998).

This article aims to present a study on osteosarcopenia in a geriatric patient.

2. Methodology

This study is a descriptive, qualitative case report (Pereira et al., 2018; Toassi & Petri, 2021) written according to CARE guidelines. We report a 70-year-old male having osteosarcopenia. The study respected ethical issues. We also performed a literature review to help readers understand how to diagnose and treat osteosarcopenia.

3. Case Report

A 70-year-old male patient presented to the hospital with the chief complaint of lower back pain. The lower back pain began 3 days before admission, following a slip and fall at home. The pain is localized, doesn't radiate, and is not associated with any tingling or numbness in both legs. The pain worsens when the patient sits or engages in activities but improves when lying down. Before the fall, the patient was still able to walk with the assistance of a walker, although he used to drag his right leg and may require help with certain activities such as climbing the stairs.

The patient's urination behavior is within normal limits, and the last bowel movement (defecation) occurred 3 days ago. The patient denies experiencing headaches or vomiting. The patient has a history of right-sided weakness from 5 years ago due to a brain hemorrhage, but the current condition has improved. There is no reported history of frequent forgetfulness. Before this event, the patient was able to perform daily activities independently. The patient's medical history includes a borehole drainage surgery in 2020 for chronic subdural hemorrhage. Following this procedure, the patient experienced left sided weakness but could resume several activities independently. There is no history of diabetes mellitus or hypertension.

On physical examination, the patient had no decrease of consciousness (GCS E4V5M6), a blood pressure of 110/60 mmHg, pulse rate of 64 beats per minute, respiratory rate of 16 breaths per minute, SpO2 of 98% on room air, temperature of 36.6°C, weight of 50 kg, and height of 155 cm. Eye examination revealed no signs of anemia or jaundice. Chest was symmetric with normal S1 and S2 heart sounds, and no murmurs were detected. Pulmonary examination revealed vesicular breath sounds in both lung fields with no additional abnormal sounds such as wheezing or rhonchi. Abdominal examination showed normal bowel sounds, no distension, a liver span of 10 cm, and tympanic percussion. Extremities were within normal limits, warm to the touch, and without edema.

We performed laboratory examinations which included a complete blood count, liver and kidney function test, serum electrolytes, serum vitamin D, and thyroid function test. Laboratory examination revealed the following findings: leukocyte count within normal limits (5.72 x 10^3/uL) with lymphopenia (12.6%, 0.72 x 10^3/uL) and eosinophilia (5.40%). The erythrocyte count was lower than normal (4.02 x 10^6/uL), and the hematocrit level was also decreased (36.30%). The platelet count was lower (148.00 x 10^3/uL), and the neutrophil-to-lymphocyte ratio was elevated (5.90). Hemoglobin levels were reduced (12.00 g/dL). SGOT/AST levels were within normal limits, while SGPT/ALT levels were lower than the reference value (9.60 U/L). Blood glucose, BUN, creatinine, sodium, chloride, magnesium, thyroid hormones, and alkaline phosphatase (ALP) were within normal limits. However, eGFR was lower than the normal range (83.64). Additionally, there was a decrease in potassium (3.45 mmol/L), total 25-OH vitamin D (18.50 ng/mL), and calcium (7.8 mg/dL).

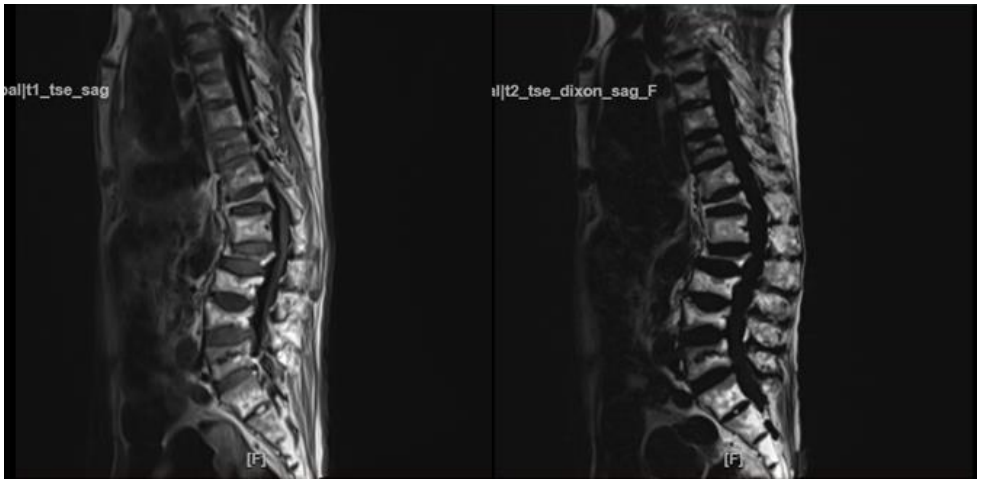
The patient's axial T1W1, T2W1 coronal, T2STIR, sagittal T1W1, T2 Dixon water and fat separation, in-phase and out-of-phase MRI without contrast, and MR myelography revealed several findings. The patient had a grade I spondylolisthesis of Th12 relative to L1, compression fractures at the vertebral levels of Th7, Th10, Th12, L2, L3, L4, and L5, with complete fractures at Th10 and L5. Additionally, it was levoscoliosis of the lumbar spine and edema in the spinal cord at the L1-L2 level. The imaging also shows degenerative changes in the spine and intervertebral discs, including a central protruded disc at T12-L1 causing grade II spinal canal stenosis, a right paracentral-foraminal bulging disc at L1-L2 causing grade I spinal canal stenosis and right neural foraminal stenosis, a diffuse bulging disc at L3-L4 causing grade I spinal canal stenosis, a right central bulging disc at L4-L5 causing grade I spinal canal stenosis and right neural foraminal stenosis, and a central bulging disc at L5-S1 causing grade I spinal canal stenosis. Further findings include fatty marrow changes from Th7-S3, disc dehydration in all visualized thoracolumbar discs, and thoracolumbar spondylosis, which can be seen in Figure 1.

Bone mineral density (BMD) testing conducted in the context of clinical osteoporosis in this patient specifically revealed that in the right forearm region, BMD at the 33% radius was 0.397 g/cm², with a T-score of -5.5. The total radius BMD was 0.277 g/cm², with a T-score of -6.6. In the left forearm region, the BMD at the 33% radius was 0.450 g/cm², with a T-score of -4.9. The total radius BMD was 0.307 g/cm², and the T-score was -6.1. For the right femur, the BMD at the femoral neck was 0.440 g/cm², with a T-score of -4.3, and the total right femur BMD was 0.489 g/cm², with a T-score of -4.1. For the left femur, the BMD at the femoral neck was 0.427 g/cm², with a T-score of -4.4, and the total left femur BMD was 0.486 g/cm², with a T-score of -4.1. The BMD of the lumbar spine (L1-L4) was 0.726 g/cm², with a T-score of -3.8. The overall impression from the BMD examination is that the lowest bone density was observed in the left femur, indicating osteoporosis. BMD scan results can be seen in Figure 2-4.

The patient was diagnosed with osteosarcopenia, vitamin D deficiency (vitamin D level of 18.5 ng/mL), compression fractures at the vertebral levels of Th7, Th10, Th12, L2, L3, L4, and L5 (AO spine type A1), history of falls with immobilization, high risk for venous thromboembolism (VTE) (Padua score of 6), a history of old hemorrhagic stroke with burrhole drainage on the left side in 2020, and controlled hypertension. The patient has impairments in vision and hearing and is severely dependent, with a negative handicap status.

The patient was prescribed the following treatment regimen: IV fluid therapy with normal saline 0.9% at 20 drops per minute, totaling 2100 cc/24 hours, as needed for daily maintenance (*Holliday-Segar*). The patient is on a diet providing 30 kcal/kg body weight/day, with 1.2 grams of protein per kg body weight/day. Compression stockings were prescribed for venous thromboembolism (VTE) prophylaxis. Additionally, the patient was given 1000 IU of oral vitamin D once daily, 500 mg of oral $CaCO_3$ once daily, and a planned administration of zoledronic acid 5 mg intravenously over 30 minutes, to be given once per year. Candesartan 16 mg was prescribed orally once daily. The neurosurgery team has planned for kyphoplasty balloon insertion at the Th12 and L2 vertebral levels (Figure 1).

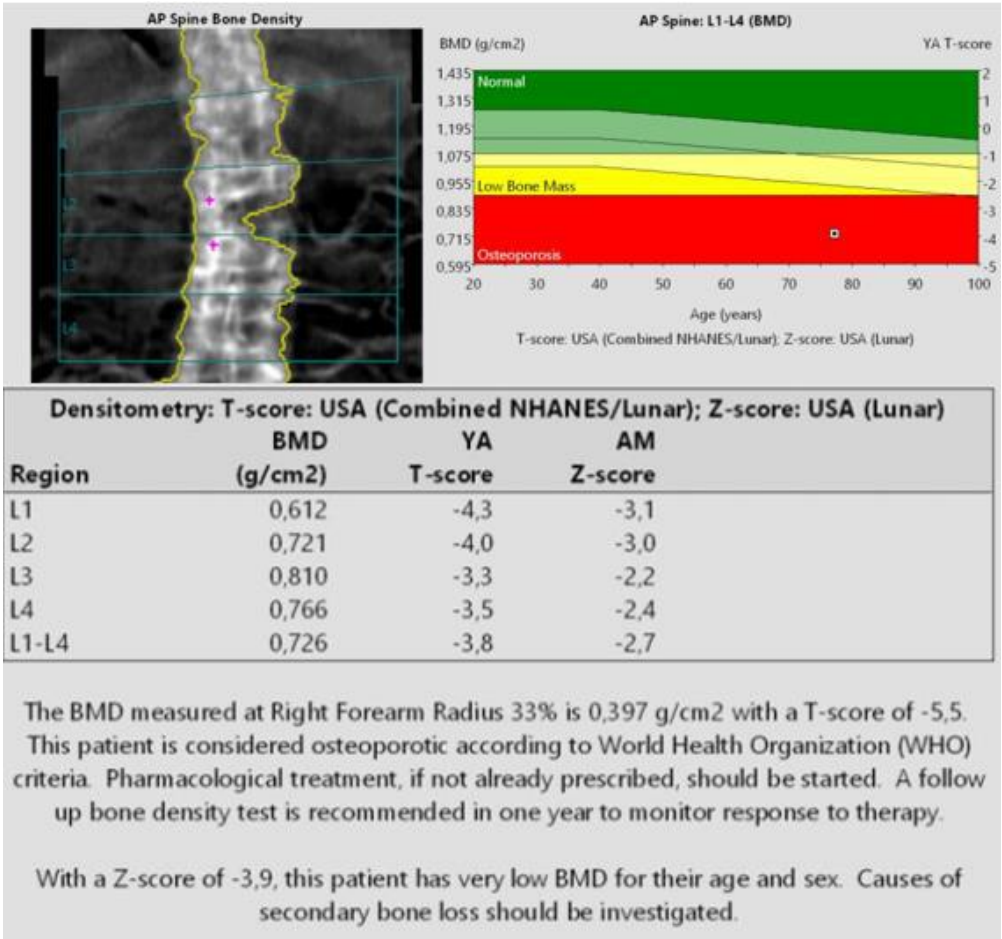
Figure 1 - Vertebral MRI Results.



Source: Authors.

Figure 1 describes vertebral MRI results: the patient had a grade I spondylolisthesis of Th12 relative to L1, compression fractures at the vertebral levels of Th7, Th10, Th12, L2, L3, L4, and L5, with complete fractures at Th10 and L5. Next, Figure 2 shows vertebral BMD Results.

Figure 2 - Vertebral BMD Results.



Densitometry: T-score: USA (Combined NHANES/Lunar); Z-score: USA (Lunar)

Region	BMD (g/cm2)	YA T-score	AM Z-score
L1	0,612	-4,3	-3,1
L2	0,721	-4,0	-3,0
L3	0,810	-3,3	-2,2
L4	0,766	-3,5	-2,4
L1-L4	0,726	-3,8	-2,7

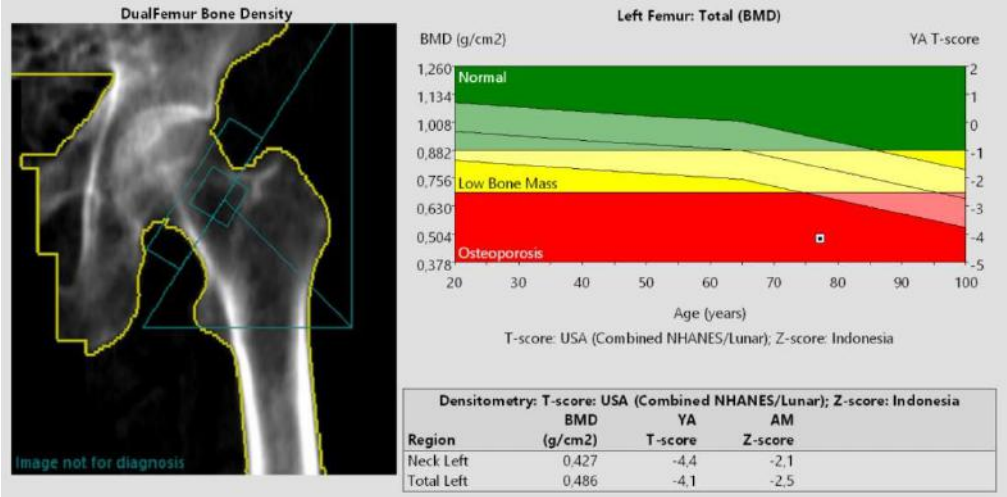
The BMD measured at Right Forearm Radius 33% is 0,397 g/cm2 with a T-score of -5,5. This patient is considered osteoporotic according to World Health Organization (WHO) criteria. Pharmacological treatment, if not already prescribed, should be started. A follow up bone density test is recommended in one year to monitor response to therapy.

With a Z-score of -3,9, this patient has very low BMD for their age and sex. Causes of secondary bone loss should be investigated.

Source: Authors.

Figure 2 describes vertebral BMD results: it shows low bone mineral density (osteoporosis). Figure 3 bellow shows Left Femur BMD Results:

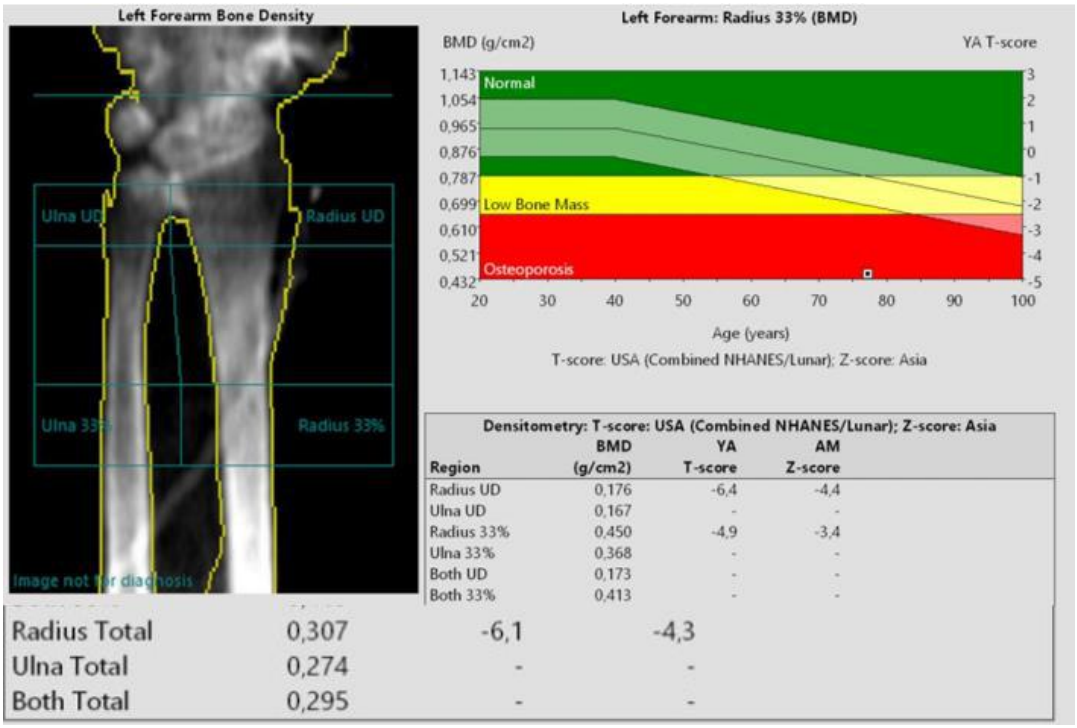
Figure 3 - Left Femur BMD Results.



Source: Authors.

Figure 3 describes left femur BMD results: low bone mineral density (osteoporosis). Next, Figure 4, shows Left Forearm BMD Results:

Figure 4 - Left Forearm BMD Results.



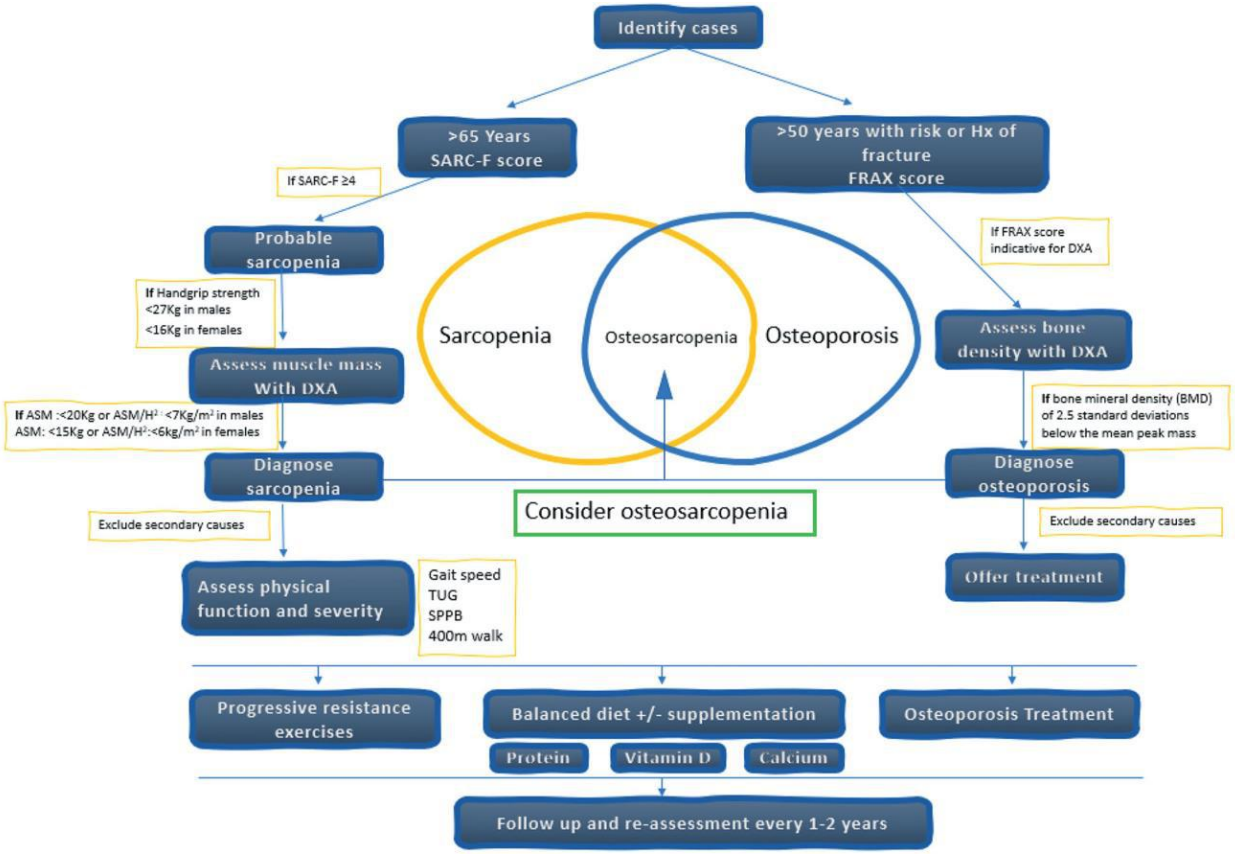
Source: Authors.

Figure 4 describes left forearm BMD results: shows low bone mineral density (osteoporosis).

4. Discussion

Osteosarcopenia is characterized by: a decline in bone mass, bone microarchitecture, muscle strength, muscle quantity, and physical ability. Patients with osteosarcopenia are often elderly, sedentary individuals, and may have various comorbidities or disabilities, resulting in a decline in function and quality of life. The most common definition of sarcopenia was proposed by the European Working Group on Sarcopenia in Older People (EWGSOP2), which suggests a diagnostic algorithm using normative grip strength reference values for healthy young adults, with cutoff points typically set at -2 or -2.5 standard deviations below the mean reference value. In recent years, muscle strength has been prioritized as a primary parameter for diagnosing sarcopenia, rather than muscle mass. Sarcopenia is suspected in patients who exhibit low muscle strength, which can be assessed through grip strength measurements using a dynamometer or by evaluating the time it takes for a patient to rise from a chair five times (Laskou et al., 2022; Polito et al., 2022). The patient in this case is a 70-year-old individual presenting with the main complaint of lower back pain that began 3 days before hospitalization, following a slip and fall incident at home. Before the fall, the patient was still able to walk with the assistance of a walker, although with right-sided foot-dragging. The risk stratification strategy can be seen in Figure 5.

Figure 5 - Risk Stratification Strategy in Osteosarcopenia**.**



Source: Laskou et al. (2022).

The causes of sarcopenia are generally attributed to the natural aging process, which is not fully understood and is multifactorial. Contributing factors to the development of osteosarcopenia include a decrease in the number and size of type II muscle fibers, inactivity, obesity, insulin resistance, a decline in androgen levels and growth factor concentrations in the serum, inadequate protein intake, reduced muscle protein synthesis that is less responsive to protein nutrition or resistance training.

Sarcopenia may also be associated with several chronic diseases that negatively affect the musculoskeletal system and physical activity. Chronic diseases linked to sarcopenia include chronic obstructive pulmonary disease (COPD), congestive heart failure, chronic kidney disease, diabetes mellitus, human immunodeficiency virus (HIV), and cancer. The role of these diseases in the development of sarcopenia can be both primary and secondary. Diseases can directly impact sarcopenia by altering muscle function, or indirectly through physical activity reduction or caloric restriction (Ardelian & Hurezeanu, 2022). A reduction in type II muscle fibers, rather than type I fibers, is observed in patients with osteosarcopenia. Several mechanisms underlying the pathophysiology of sarcopenia are as follows. Normal physiological levels of anabolic hormones in the serum, such as testosterone, human growth hormone (HGH), and insulin-like growth factor-1 (IGF-1), have been shown to play a role in the development, maintenance, and muscle tissue regeneration. However, these anabolic hormones decrease with age, particularly in elderly patients experiencing sarcopenia. Aging individuals often experience changes in body composition, characterized by an increase in adipose tissue followed by a decrease in muscle mass, a condition known as sarcopenic obesity. These changes are associated with metabolic dysfunction, including insulin resistance, which leads to visceral fat. Furthermore, insulin resistance is inversely related to skeletal muscle mass. This occurs because insulin resistance disrupts the anti-proteolytic and muscle protein synthesis-promoting effects of hormones on skeletal muscle tissue. The reduction in lean body mass impairs glucose uptake into skeletal muscle, further supporting the development of insulin resistance. Progressive neurodegeneration is a common phenomenon observed in the elderly population. Aging is associated with a reduction in alpha motor neurons in the spinal cord, loss of peripheral nerve fibers, and a reduction of neuromuscular junctions. Additionally, elevated levels of C-reactive protein (CRP), tumor necrosis factor-alpha (TNF-α), interleukin-6 (IL-6), and interleukin-1 (IL-1) are observed in older individuals. The catabolic effects of these cytokines on skeletal muscle are well-documented and may play a role in the development of sarcopenia as aging progresses (Ardelian & Hurezeanu, 2022). The European Working Group on Sarcopenia in Older People 2 (EWGSOP2) and the Asian Working Group on Sarcopenia (AWGS) have an international consensus that sarcopenia should be diagnosed using gait ability, muscle strength, and muscle mass. Furthermore, intervention decisions should be based on the level of gait ability and muscle mass (Chen et al., 2020; Cruz-Jentoft et al., 2019; Huang et al., 2021).

The SARC-F questionnaire (strength, assistance with walking, rising from a chair, climbing stairs, and falls) is a screening tool that can be quickly implemented by clinicians to identify patients who may be experiencing osteosarcopenia. This questionnaire consists of self-reported parameters related to strength, walking, rising from a chair, climbing stairs, and falls. Each parameter is scored from 0 to 2, with a maximum possible score of 10. Studies have found that a SARC-F score greater than 4: is a predictor of the need for further comprehensive evaluation. In this case, the patient experienced a fall after slipping at home (score 1), which resulted in lower back pain and limitations in activity and sitting (score 1). Before the fall, the patient was still able to walk with the assistance of a walker (score 2), although dragging the right foot due to a history of a brain hemorrhage 5 years ago. The patient also required assistance for certain activities, such as climbing stairs (score 2). Therefore, the patient's SARC-F score is 6 (above 4). A diagnosis of severe sarcopenia is made when there is weak muscle strength accompanied by low muscle quantity and a decline in physical ability, such as slower gait speed (Laskou et al., 2022).

5. Conclusion

This study reports the case of a 70-year-old male patient with osteosarcopenia presenting to the hospital with a chief complaint of lower back pain. To facilitate potential sarcopenia identification, in patients, SARC-F tests could be quickly implemented by clinicians. If the patient's SARC-F score is >4, a more comprehensive evaluation is required to confirm the diagnosis of sarcopenia. The FRAX score is a validated screening tool for identifying osteoporosis in patients. Osteosarcopenia

serves as a poor prognostic indicator in various medical conditions and surgical procedures. Therefore, adequate prevention and management are essential to maintain the quality of life in the elderly population.

References

Ardeljan, A. D., & Hurezeanu, R. (2022). Sarcopenia. *IntechOpen*. https://doi.org/10.5772/intechopen.98234.

Barnsley, J., Buckland, G., Chan, P. E., Ong, A., Ramos, A. S., Baxter, M., Beresford, L. S., Cooper, C., Dennison, E. M., & Howe, S. (2021). Pathophysiology and treatment of osteoporosis: Challenges for clinical practice in older people. *Aging Clinical and Experimental Research*, 33 (4), 759–73. https://doi.org/10.1007/s40520-021-01635-4.

Chen, L. K., Woo, J., Assantachai, P., Auyeung, T. W., Chou, M. Y., Iijima, K., & Arai, H. (2020). Asian Working Group for Sarcopenia: 2019 Consensus update on sarcopenia diagnosis and treatment. *Journal of the American Medical Directors Association*, 21(3), 300-7. e2. https://doi.org/10.1016/j.jamda.2019.12.024.

Cruz-Jentoft, A. J., Bahat, G., Bauer, J., Boirie, Y., Bruyère, O., Cederholm, T., Landi, F., Martin, F. C., Michel, J. P., Rolland, Y., & Zamboni, M. (2019). Sarcopenia: Revised European consensus on definition and diagnosis. *Age and Ageing*, 48(4), 601–601. https://doi.org/10.1093/ageing/afz01.7

Daly, R. M., Gianoudis, J., Kersh, M. E., Bailey, C. A., Ebeling, P. R., Krug, R., van den Heuvel, E., & West, M. (2020). Effects of a 12-month supervised, community-based, multimodal exercise program followed by a 6-month research-to-practice transition on bone mineral density, trabecular microarchitecture, and physical function in older adults: A randomized controlled trial. *Journal of Bone and Mineral Research*, 35(3), 419–429. https://doi.org/10.1002/jbmr.3974.

Edwards, M. H., Gregson, C. L., Patel, H. P., Jameson, K. A., Harvey, N. C., Sayer, A. A., Dennison, E. M., & Cooper, C. (2013). Muscle size, strength, and physical performance and their associations with bone structure in the Hertfordshire Cohort Study. *Journal of Bone and Mineral Research*, 28(11), 2295–304. https://doi.org/10.1002/jbmr.1921.

Ferretti, J. L., Capozza, R. F., Cointry, G. R., García, S. L., Plotkin, H., Alvarez Filgueira, M. L., Bernini, E., Brunner, L., & Kausz, A. (1998). Gender-related differences in the relationship between densitometric values of whole-body bone mineral content and lean body mass in humans between 2 and 87 years of age. *Bone*, 22(6), 683–90. https://doi.org/10.1016/S8756-3282(98)00073-9.

Huang, C. F., Shiao, M. S., & Mao, T. Y. (2021). Retrospective study of the effects of zoledronic acid on muscle mass in osteoporosis patients. *Drug Design, Development and Therapy*, 15, 3711–5. https://doi.org/10.2147/DDDT.S322679.

Ilesanmi-Oyelere, B. L., Coad, J., Roy, N., & Kruger, M. C. (2018). Lean body mass in the prediction of bone mineral density in postmenopausal women. *Biores Open Access*, 7(1), 150–8. https://doi.org/10.1089/biores.2018.0023.

Intriago, M., Maldonado, G., Guerrero, R., Messina, O. D., & Rios, C. (2020). Bone mass loss and sarcopenia in Ecuadorian patients. *Journal of Aging Research*, 2020, 1–6. https://doi.org/10.1155/2020/4817037.

Johnell, O., & Kanis, J. A. (2006). An estimate of the worldwide prevalence and disability associated with osteoporotic fractures. *Osteoporosis International*, 17(12), 1726–33. https://doi.org/10.1007/s00198-006-0172-4.

Kirk, B., Mooney, K., Cousins, R., Angell, P., Jackson, M., Pugh, J. N., Price, A., & Cates, M. (2020). Effects of exercise and whey protein on muscle mass, fat mass, myoelectrical muscle fatigue and health-related quality of life in older adults: A secondary analysis of the Liverpool Hope University—Sarcopenia Ageing Trial (LHU-SAT). *European Journal of Applied Physiology*, 120 (2), 493–503. https://doi.org/10.1007/s00421-020-04374-6.

Leslie, W. D., Schousboe, J. T., Morin, S. N., Martineau, P., Lix, L. M., Johansson, H., Harvey, N. C., & Kanis, J. A. (2020). Loss in DXA-estimated total body lean mass but not fat mass predicts incident major osteoporotic fracture and hip fracture independently from FRAX: A registry-based cohort study. *Archives of Osteoporosis*, 15 (1), 96. https://doi.org/10.1007/s11657-020-00841-0.

Laskou, F., Patel, H. P., Cooper, C., & Dennison, E. (2022). A pas de deux of osteoporosis and sarcopenia: Osteosarcopenia. *Climacteric*, 25, 88–95. https://doi.org/10.1080/13697137.2022.2044770.

Locquet, M., Beaudart, C., Reginster, J. Y., & Bruyère, O. (2019). Association between the decline in muscle health and the decline in bone health in older individuals from the SarcoPhAge cohort. Calcified Tissue International, 104(3), 273–284. https://doi.org/10.1007/s00223-019-00491-x.

Maggi, S., & Falaschi, P. (2022). *Orthogeriatrics*: The management of older patients with fragility fractures (2nd ed.). Springer. https://doi.org/10.1007/978-3-030-61119-3.

Paintin, J., Cooper, C., & Dennison, E. (2018). Osteosarcopenia. *British Journal of Hospital Medicine*, 79(5), 253–8. https://doi.org/10.12968/hmed.2018.79.5.253.

Pereira A. S. et al. (2018). *Metodologia da pesquisa científica*. [free e-book]. Santa Maria/RS. Ed. UAB/NTE/UFSM.

Pizzonia, M., Casabella, A., Natali, M., Petrocchi, L., Carmisciano, L., Nencioni, A., Giusti, A., & Ferrone, F. (2021). Osteosarcopenia in very old age adults after hip fracture: A real-world therapeutic standpoint. *Frontiers in Medicine*, 8, 682013. https://doi.org/10.3389/fmed.2021.682013.

Polito, A., Barnaba, L., Ciarapica, D., & Azzini, E. (2022). Osteosarcopenia: A narrative review on clinical studies. *International Journal of Molecular Sciences*, 23(24), 8343. https://doi.org/10.3390/ijms23248343.

Rizzoli, R., Stevenson, J. C., Bauer, J. M., van Loon, L. J. C., Walrand, S., Kanis, J. A., & Reginster, J. Y. (2014). The role of dietary protein and vitamin D in maintaining musculoskeletal health in postmenopausal women: A consensus statement from the European Society for Clinical and Economic Aspects of Osteoporosis and Osteoarthritis (ESCEO). *Maturitas*, 79(1), 122–32. https://doi.org/10.1016/j.maturitas.2014.07.005.

Rosenberg, I. H. (2011). Sarcopenia: Origins and clinical relevance. *Clinical Geriatrics Medicine*, 27(3), 337–339. https://doi.org/10.1016/j.cger.2011.03.002.

Toassi, R. F. C. & Petry, P. C. (2021). *Metodologia científica aplicada à área da Saúde*. (2ed.). Editora da UFRGS.

Vinícius-Souza, G. E., Noll, M., & Silveira, E. A. (2021). Effectiveness of exercise for osteosarcopenia in older adults: A systematic review protocol. *BMJ Open*, 11(11), e047671. https://doi.org/10.1136/bmjopen-2021-047671.