Nutrición Hospitalaria

Utilidad del Mini-Nutritional Assessment en la detección de sarcopenia en una muestra de personas mayores institucionalizadas: un estudio transversal

Usefulness of the Mini-Nutritional Assessment in screening for sarcopenia in a sample of institutionalized older persons - A cross-sectional study

10.20960/nh.05491

03/05/2025

OR 5491

Usefulness of the Mini-Nutritional Assessment in screening for sarcopenia in a sample of institutionalized older persons - A cross-sectional study

Utilidad del Mini-Nutritional Assessment *en la detección de sarcopenia en una muestra de personas mayores institucionalizadas: un estudio transversal*

Ashuin Kammar-García[1], Esmeralda Garza-Santiago[2], Javier Mancilla-Galindo[3], Orietta Segura-Badilla[4], Martín Lazcano-Hernández[5], Obdulia Vera-López[5], Addi Rhode Navarro-Cruz[5]

[1]Research Direction. Instituto Nacional de Geriatría. Ciudad de México, Mexico. [2]Faculty of Health Sciences. Universidad Anáhuac. Ciudad de México, Mexico. [3]Institute for Risk Assessment Sciences (IRAS). Utrecht University. Utrecht, The Netherlands. [4]Faculty of Health and Food Sciences. Universidad del Bío-Bío. Chillán, Chile. [5]Faculty of Chemical Sciences. Benemérita Universidad Autónoma de Puebla. Puebla, Mexico

Received: 10/10/2024
Accepted: 04/02/2025
Correspondence: Esmeralda Garza-Santiago. Faculty of Health Sciences. Universidad Anáhuac. Ciudad de México, Mexico
e-mail: akammar@inger.gob.mx

Authors' contribution: Ashuin Kammar-García: writing-original draft, writing-review and editing, formal analysis. Javier Mancilla-Galindo: supervision, software. Esmeralda Garza-Santiago: validation, visualization, writing-original draft. Addi Rhode Navarro-Cruz: resources,

conceptualization. Orietta Segura-Badilla: data curation, funding acquisition. Obdulia Vera-López: investigation. Martín Lazcano-Hernández: investigation, methodology.

Conflict of interest: The authors declare no conflict of interest.

Artificial intelligence: In this manuscript, Grammarly and ChatGPT-4o were tools used to translate into English, check grammar, and improve the clarity of the writing.

ABSTRACT

Background: sarcopenia is a disease associated with muscle changes during aging, and its detection remains a challenge outside specialized clinical units.

Objective: to evaluate the utility of the Mini-Nutritional Assessment (MNA) in detecting sarcopenia in institutionalized older persons.

Materials and methods: we conducted a cross-sectional study in adults aged 55 and older from Puebla. We administered both the short form (SF) and the complete form (LF) of the MNA. We diagnosed sarcopenia according to EWGSOP2 criteria. We plotted the points obtained from MNA-SF and MNA on a ROC curve. We evaluated the odds ratio (OR) for presenting sarcopenia based on the recommended cutoff points using logistic regression models adjusted for age and sex.

Results: the study included 162 participants, with 64.1 % of them being women, and the mean age was 69.8 years (SD: 5). The mean scores of MNA-SF and MNA-LF were 12.17 (SD: 1.78), and 25.1 (SD: 2.83), respectively. The prevalence of sarcopenia was 20.4 %. The AUC of MNA-SF was 0.68 (95 % CI: 0.58-0.78), and for MNA-LF, 0.60 (95 % CI: 0.49-0.71). The OR for presenting sarcopenia with MNA-SF < 12 was

OR = 2.87 (95 % CI: 1.31-6.29) and, after adjustment for age and sex, OR = 2.47 (95 % CI: 1.10-5.54).

Conclusions: according to AUC, MNA-SF may help detect sarcopenia in institutionalized older persons, while MNA-LF may have reduced utility in practice.

Keywords: Sarcopenia. Malnutrition. Mini-Nutritional Assessment. Nutrition. Older persons.

RESUMEN

Antecedentes: la sarcopenia es una enfermedad asociada con cambios musculares durante el envejecimiento, y su detección sigue siendo un desafío fuera de las unidades clínicas especializadas.

Objetivo: evaluar la utilidad del *Mini-Nutritional Assessment* (MNA) en la detección de sarcopenia en personas mayores institucionalizadas.

Materiales y métodos: estudio transversal en adultos de 55 años y más de la ciudad de Puebla. Se administró el MNA en su forma corta (SF) y forma completa (LF). El diagnóstico de sarcopenia se realizó según EWGSOP2. Los puntos obtenidos de MNA-SF y MNA se representaron en una curva ROC. Se evaluó el odds ratio (OR) de presentar sarcopenia según puntos de corte recomendados con modelos de regresión logística, ajustados por edad y sexo.

Resultados: se incluyeron 162 participantes, el 64,1 % fueron mujeres, la edad media fue 69,8 años (DE: 5). Las puntuaciones medias de MNA-SF y MNA-LF fueron 12,17 (DE: 1,78) y 25,1 (DE: 0,83), respectivamente. La prevalencia de sarcopenia fue del 20,4 %. El AUC de MNA-SF fue 0,68 (IC 95 %: 0,58-0,78) y para MNA-LF, 0,60 (IC 95 %: 0,49-0,71). El OR de presentar sarcopenia con MNA-SF < 12 fue OR = 2,87 (IC 95 %: 1,31-6,29) y, tras ajustar por edad y sexo, OR = 2,47 (IC 95 %: 1,10-5,54).

Conclusiones: según la AUC, MNA-SF puede ser útil para detectar sarcopenia en personas mayores institucionalizadas, mientras que MNA-LF puede tener una utilidad reducida en la práctica.

Palabras clave: Sarcopenia. Desnutrición. *Mini-Nutritional Assessment.* Nutrición. Personas mayores.

INTRODUCTION

The proportion of older adults in the global population has been steadily rising. With increasing life expectancy, the distribution is shifting towards more advanced ages. According to estimates by the World Health Organization (1), by the year 2050, individuals over 60 are expected to represent 22 % of the world's population. In Mexico, 17,958,707 people aged 60 or older were estimated to reside, representing 14 % of the country's population (2).

Sarcopenia is a progressive and widespread muscular disease (muscular atrophy) that originates from adverse muscular changes that accumulate throughout life (3). According to its etiology, it can be divided into primary (age-related) when there is no specific evident cause and secondary (disease, inactivity, or malnutrition) (4). Sarcopenia is associated with high personal, social, and economic burdens (5), increases the risk of falls and fractures (6,7), leads to a lower quality of life (8), loss of independence, or the need for long-term care (9-11), and higher mortality (12). It affects between 5 % and 13 % of adults aged 60 to 70 years and 50 % of adults over 80 years old. By the year 2025, sarcopenia will likely affect 1.2 billion people, and by 2050, researchers expect this number to reach 2 billion patients (13).

Malnutrition is considered one of the leading causes of sarcopenia, with the coexistence of nutritional alterations such as low dietary intake and weight loss with a decrease in muscle mass and strength (14,15). Therefore, researchers have proposed nutritional screening tools as helpful in screening for sarcopenia in older adults. Researchers consider the Mini-Nutritional Assessment (MNA) a highly sensitive and specific nutritional screening tool to assess the risk of malnutrition (16), and they have recently proposed it as a potential tool for evaluating sarcopenia in hospitalized older adults (17,18). However, to our knowledge, its usefulness outside of hospital settings has not been evaluated, specifically in Nursing Homes or Day Centers where the infrastructure (human and material resources) to carry out
complex assessments of nutritional status is insufficient. Therefore, the study's objective is to evaluate the utility of the Mini-Nutritional Assessment (MNA) in detecting sarcopenia in institutionalized older persons.

MATERIAL AND METHODS

Study design and setting

A cross-sectional study was conducted from May to August 2021 in institutionalized older adults at the day center “La Casa del Jubilado,” which is for retired individuals formerly employed by the Benemérita Universidad Autónoma de Puebla, located in the city of Puebla, Mexico. The ethics and research committee of the Benemérita Universidad Autónoma de Puebla approved the present study (C.Q./CT 052P/2021).

Participants

The study included individuals over 55 with normal cognitive function, determined by a score greater than 14 on the abbreviated Mini-Mental State Examination and the ability to walk, who provided informed consent to participate. Exclusion criteria were the presence of eating

disorders and the use of specialized diets or nutritional treatments. Elimination criteria included withdrawal of consent for participation and incomplete data during anthropometric and functionality assessments.

Data collection and measurements

Anthropometric and body composition measurements

We collected anthropometric measurements such as weight, height, waist circumference, calf circumference, mid-upper arm circumference, and calf skinfold. A certified anthropometrist performed all measurements, ensuring the data's reliability and accuracy. The anthropometrist followed the measurement standards established by the International Society for the Advancement of Kinanthropometry.

For obtaining body weight, the anthropometrist used a SECA Mod 813 floor scale with a precision of 100 g, height was measured using a SECA Mod 225 stadiometer with an accuracy of 0.1 cm, and waist, arm, and calf circumferences were measured using a SECA Mod 201 measuring tape. We measured waist circumference above the upper border of the iliac crests (approximately at the navel level). Calf circumference was measured at the most prominent part of the calf while keeping the leg at a 90° angle. Mid-upper arm circumference was measured at the midpoint between the acromion process of the scapula and the olecranon process (elbow) on the non-dominant arm when relaxed. We measured the calf skinfold on the medial side of the lower leg at the greatest circumference of the calf.

The anthropometrist measured body fat percentage using bioimpedance analysis (Biodynamics Body Cell Mass Analyzer Mod 550, Washington, USA) following the manufacturer's standardized protocol.

Mini-Nutritional Assessment

We used both the Mini-Nutritional Assessment in its short version (MNA-SF) and its extended version (MNA-LF) (19,20). Healthcare workers with

prior training in the Mini-Nutritional Assessment applied the questionnaire. The MNA-SF consists of 6 items: BMI, recent weight loss, appetite or eating problems, mobility impairment, acute illness/psychological stress, and dementia or depression. In contrast, the MNA-LF comprises 18 items, including the first 6 items of the MNA-SF, plus 12 additional items covering aspects such as muscle mass (arm circumference and calf circumference), lifestyle, mobility, medication, number of meals, protein sources consumption, fruits and vegetables intake, fluids, and self-perception of health. You can find the Spanish adaptations of both questionnaires at the following link: https://www.gob.mx/inger/documentos/guia-de-instrumentos-de-evaluacion-de-la-capacidad-funcional.

We classified the subjects into three nutritional status categories based on the scores obtained in each test. These categories are normal nutritional status (MNA-SF: 12-14, MNA-LF: 24-30), risk of malnutrition (MNA-SF: 8-11, MNA-LF: 17-23.5), and malnutrition (MNA-SF: < 7, MNA-LF: < 17).

Sarcopenia evaluation

To diagnose sarcopenia, we used the classification of the European Working Group on Sarcopenia in Older People 2 (EWGSOP2). This classification categorizes sarcopenia as probable due to low muscle strength, confirmed sarcopenia due to low muscle strength and low muscle quantity or quality, and severe sarcopenia due to both conditions plus low physical performance (4).

Following the Southampton protocol, we used a Jamar hand dynamometer (5030J1) to assess muscle strength (21). We obtained the highest score from 6 measurements (3 per arm) and recorded it to the nearest 1 kg. We classified muscle strength as low according to the cutoff points of EWGSOP2, which are < 27 kg for men and < 16 kg for women.

We assessed muscle mass quantity by calculating appendicular skeletal muscle mass adjusted for height (ASMM/height^2). We calculated ASMM using the anthropometric equation by Kawakami et al. 2021 (22). We classified muscle mass as low according to the cutoff points of EWGSOP2, which are < 7.0 kg/m^2 for men and < 5.5 kg/m^2 for women.
We assessed physical performance using the 4-m gait speed test, recording the time in seconds it takes the subject to walk 4 meters without stopping. We calculated the speed in m/s and classified physical performance as low according to the EWGSOP2 cutoff points, which are < 0.8 m/s for both men and women.

Statistical methods

For this study, we did not calculate the sample size. Instead, we invited all staff enrolled in the Day Center “La Casa del Jubilado,” achieving 100 % participation from the institutionalized older adults. We present the sample's descriptive data as mean, standard deviation, and range. We present the scores of MNA-SF and MNA-LF as median and interquartile ranges. We report the presence of sarcopenia at each stage, along with low muscle strength, mass, and performance, as frequency and percentage. We calculated the 95 % confidence interval (95 % CI) through bootstrapping with 1000 iterations.
We plotted the scores of MNA-SF and MNA-LF on a ROC curve and obtained the areas under the ROC curve (AUC) with their 95 % CI, along with the cutoff points for sensitivity and specificity values. We also calculated the sensitivity and specificity of the recommended cutoff point for each MNA to define an alteration in nutritional status (MNA-SF < 12 and MNA-LF < 24).
We performed various logistic regression models to estimate the odds of presenting sarcopenia and each of its criteria according to the cutoff points suggested by the ROC curve and those used to assess an alteration in nutritional status for each version of the MNA. We present

the data as Odds Ratios (OR) with their 95 % CI for each univariable model and models adjusted by sex and age (quantitative). We evaluated the models' assumptions through residual analysis.

We considered a significance level of $p < 0.05$ as statistically significant. We performed all analyses using SPSS software v.21 and created the graphs using GraphPad Prism software v.10.2.2.

RESULTS

A total of 164 subjects met the inclusion criteria for the study. We excluded two subjects for not completing the muscle strength evaluation protocol, leaving 162 participants in the analysis, of which 64.1 % (n = 103) were women. The mean age was 69.8 years (SD: 5.5). Among the subjects, 18.5 % (n = 30) were aged 55-65 years, 66 % (n = 107) were aged 65-75 years, 14.3 % (n = 23) were aged 75-85 years, and 1.2 % (n = 2) were older than 85 years. Regarding BMI, 6.8 % (n = 11) of the subjects had a BMI < 22, 35.8 % (n = 58) had a BMI between 22-26.9, 27.2 % (n = 44) had a BMI between 27-29.9, and 30.2 % (n = 49) had a BMI ≥ 30. We present the descriptive results of the study sample in Table I.

Regarding sarcopenia criteria results, we observed that the maximum dynamometry of the subjects was 17.90 (SD: 6.34) in women and 23.72 (SD: 5.15) in men. The ASMM/height^2 was 6.53 (SD: 1.03) in women and 7.91 (SD: 1.10) in men. The gait speed was 1.03 (SD: 0.33). We classified 72.2 % (95 % CI: 65.4-79.0) of the participants with low muscle strength, 20.4 % (95 % CI: 14.2-27.2) with low muscle mass, and 34 % (95 % CI: 27.2-41.4) with low muscle performance. Of the total sample, we diagnosed 33 subjects (20.4 %, 95 % CI: 14.2-27.2) with sarcopenia, of which 12 (36.4 %, 95 % CI: 19.0-53.7) had severe sarcopenia. Tables II and III present the data on body composition, strength, mass, and muscle performance among the classifications of MNA-SF and MNA-LF, respectively.

Figure 1 shows the ROC curves of MNA-SF (Fig. 1A) and MNA-LF (Fig. 1B) for sarcopenia detection. The AUC of MNA-SF was 0.68 (95 % CI: 0.58-0.78), and of MNA-LF was 0.60 (95 % CI: 0.49-0.71). The suggested cutoff point for sarcopenia detection by MNA-SF was < 13 and < 25.5 for MNA-LF. Figure 2 shows ROC curves for detecting each criterion for sarcopenia diagnosis.

Table IV shows the sensitivity and specificity values for the suggested cutoff points for both MNAs and those recommended to define an alteration in nutritional status for sarcopenia detection and each diagnostic criterion. We observed that the cutoff points MNA-SF < 12 and MNA-LF < 24 showed higher sensitivity for detecting sarcopenia, low strength, and low muscle mass.

Table V shows the results of logistic regression models to determine the odds of detecting sarcopenia and each component by the cutoff points of MNA-SF and MNA-LF. Subjects with MNA-SF < 13 had two times higher odds of presenting sarcopenia (OR = 2.36, 95 % CI: 1.02-5.45, p = 0.04) after adjustment for sex and age, la MNA-SF < 12 had a similar result (OR = 2.87, 95 % CI: 1.31-6.29, p = 0.03); while MNA-LF cutoff points were not associated with sarcopenia. To determine each criterion of sarcopenia diagnosis, we found that MNA-SF was associated with low muscle mass at both cutoff points, and MNA-LF was associated with low muscle strength at the < 25.5 cutoff point.

DISCUSSION

In the present study, our objective was to evaluate the utility of the Mini-Nutritional Assessment (MNA) in detecting sarcopenia in institutionalized older persons. We observed that the MNA in its short version is associated with the presence of sarcopenia and that the cutoff point associated with sarcopenia is the point that defines an alteration in nutritional status (MNA-SF < 12). Thus, subjects with an alteration in

nutritional status had twice the odds of presenting sarcopenia than those with normal nutritional status.

MNA-SF and MNA-LF have high sensitivity and specificity for detecting malnutrition (16). What differentiates them is that the MNA-LF collects more dietary intake and muscle mass information than the MNA-SF. Despite the evidence on the relationship between dietary intake and sarcopenia (14), our study did not observe an association between MNA-LF and sarcopenia.

Our findings replicate the findings of other authors in recent years. However, the difference in our study is that it is the first to evaluate the utility of the MNA in detecting sarcopenia in institutionalized older persons. Other researchers have conducted previous studies on older hospitalized persons. In 2020, Zhang et al. (18) examined the efficacy of MNA-SF for sarcopenia detection in hospitalized older persons, observing an AUC of 0.76 (95 % CI 0.72-0.81). Additionally, they observed that patients with sarcopenia and malnutrition by MNA-SF had lower survival in a 20-month follow-up. In this study, 66.4 % of patients with sarcopenia had malnutrition, whereas in our study, 54.5 % of patients with sarcopenia were at risk of malnutrition. Another study conducted in hospitalized patients in 2017 (17) showed similar results to Zhang's findings. MNA-SF had an AUC of 0.76 for sarcopenia detection in individuals aged 65 years and older according to EWGSOP criteria.

The most recent study, conducted in China in 2023 (23), is particularly noteworthy as it focused on outpatient patients, a population similar to ours. This study found that MNA-SF, when used with a cutoff point of 12 points, had an AUC of 0.80 (95 % CI: 0.72-0.87), with a sensitivity of 66.6 % and specificity of 85.8 %; nonetheless, they used EWGSOP criteria, which prioritize muscle mass over strength for sarcopenia detection.

The Global Leadership Initiative on Malnutrition also establishes reduced muscle mass or quality as a phenotypic criterion for adult malnutrition in

clinical settings (24). We evaluated this through tests such as dual-energy X-ray absorptiometry (DXA) or other validated body composition measures, including bioelectrical impedance analysis (BIA), ultrasound, computed tomography (CT), and magnetic resonance imaging or magnetic resonance spectroscopy. However, these methods are not always available in most clinical or nutritional care settings, especially in primary or geriatric care centers. In these latter settings, using more accessible and straightforward assessment methods, such as physical examination, anthropometric measurements of calf or arm muscle circumferences, and strength testing through dynamometry, becomes relevant. However, even in geriatric care centers, these tools may not be available, and the lack of trained personnel for their use and evaluation is associated with malnutrition (25) and low improvement in the nutritional status of older persons (26).

Institutionalized older adults have a lower quality of life and a higher risk of developing a worse overall health status (25). Researchers in Mexico have found that institutionalized older persons face factors such as polypharmacy, depression, and lack of trained personnel, which are associated with their nutritional deterioration (27). Therefore, our findings may provide evidence of the utility of a rapid, easy-to-administer nutritional screening test that does not require training and can detect sarcopenia in ambulatory older persons. The implementation of the Mini-Nutritional Assessment in non-hospital settings could support the more efficient use of limited resources already existing in Nursing Homes or Day Centers, enabling the single use of a screening test to assess nutritional status and sarcopenia without the need to implement further screening, and additionally contributing to the detection of any possible secondary cause of sarcopenia based on the questions in the Mini-Nutritional Assessment.

Our study has several limitations, mainly the relatively small sample size for an epidemiological study. We did not calculate the sample size. Still,

our findings provide a first approach to evaluating the Mini-Nutritional Assessment's diagnostic potential in detecting sarcopenia, which could be helpful for future studies. In our study, we noted an association with low muscle strength. It is essential to emphasize the possibility that this finding may be a type 2 error due to the lack of power in our study. More research is required to determine whether our findings are replicable, as other studies exploring similar research questions have only used the MNA-SF.

The results obtained in our sample, which indicate a higher prevalence of muscle weakness compared to significant muscle mass loss, may be explained by the characteristics of the study participants. The sample consisted of older adults institutionalized in a day care center, where they receive care and participate in activities exclusively during the day. All participants spent the night at their own homes or with caregivers, which likely influenced the type of care they received. This arrangement may have contributed to the partial preservation of muscle mass but was insufficient to maintain optimal muscle health.

These findings are relevant as they may impact the external validity of our results. Therefore, it is crucial to continue investigating this topic to confirm and expand upon the evidence presented in this study.

It is necessary to continue research on applying various nutritional screening tests and their association with sarcopenia. On the other hand, although our study's cross-sectional design is suitable for our objective, the lack of follow-up does not allow us to know if subjects who did not present sarcopenia but did have a nutritional alteration could develop sarcopenia over time.

CONCLUSION

In conclusion, according to AUC, MNA-SF may help detect sarcopenia in institutionalized older persons, while MNA-LF may have reduced utility in practice. The main criterion associated with MNA-SF is low muscle mass.

Efforts should be directed towards conducting research in institutionalized populations of older persons to determine the feasibility of using simple tools for sarcopenia detection and the effects of such early detections as a call to action for improving and preventing nutritional disorders.

Declarations

Ethics approval and consent to participate: The Research Ethics Committee of the National Institute of Geriatrics approved this study.

REFERENCES

1. World Health Organization. [Internet]. Geneva: WHO, cop; c2022 [cited 2024 Apr 13]. Ageing and health; [about 2 screens] Available from: https://www.who.int/news-room/fact-sheets/detail/ageing-and-health
2. Instituto Nacional de Estadística y Geografía. Comunicado de prensa núm. 568/22: Estadísticas a propósito del día internacional de las personas adultas mayores [Internet]. México: INEGI; c2022 [cited 2024 Apr 13]. Available from: https://www.inegi.org.mx/contenidos/saladeprensa/aproposito/2022/EAP_ADULMAY2022.pdf
3. Anker SD, Morley JE, Haehling S. Welcome to the ICD-10 code for sarcopenia. J Cachexia Sarcopenia Muscle 2016;7(5):512-4. DOI: 10.1002/jcsm.12147
4. Cruz-Jentoft AJ, Bahat G, Bauer J, Boirie Y, Bruyère O, Cederholm T, et al. Sarcopenia: revised European consensus on definition and diagnosis. Age Ageing 2018;48(1):16-31. DOI: 10.1093/ageing/afy169

5. Mijnarends DM, Luiking YC, Halfens RJ, Evers SM, Lenaerts EL, Verlaan S, et al. Muscle, Health and Costs: A Glance at their Relationship. J Nutr Health Amp Aging 2018;22(7):766-73. DOI: 10.1007/s12603-018-1058-9
6. Bischoff-Ferrari HA, Orav JE, Kanis JA, Rizzoli R, Schlögl M, Staehelin HB, et al. Comparative performance of current definitions of sarcopenia against the prospective incidence of falls among community-dwelling seniors age 65 and older. Osteoporos Int 2015;26(12):2793-802. DOI: 10.1007/s00198-015-3194-y
7. Schaap LA, van Schoor NM, Lips P, Visser M. Associations of Sarcopenia Definitions, and Their Components, With the Incidence of Recurrent Falling and Fractures: The Longitudinal Aging Study Amsterdam. J Gerontol 2017;73(9):1199-204. DOI: 10.1093/gerona/glx245
8. Beaudart C, Biver E, Reginster JY, Rizzoli R, Rolland Y, Bautmans I, et al. Validation of the SarQoL®, a specific health-related quality of life questionnaire for Sarcopenia. J Cachexia Sarcopenia Muscle 2016;8(2):238-44. DOI: 10.1002/jcsm.12149
9. dos Santos L, Cyrino ES, Antunes M, Santos DA, Sardinha LB. Sarcopenia and physical independence in older adults: the independent and synergic role of muscle mass and muscle function. J Cachexia Sarcopenia Muscle 2016;8(2):245-50. DOI: 10.1002/jcsm.12160
10. Akune T, Muraki S, Oka H, Tanaka S, Kawaguchi H, Tokimura F, et al. Incidence of certified need of care in the long-term care insurance system and its risk factors in the elderly of Japanese population-based cohorts: The ROAD study. Geriatr Amp Gerontol International 2013;14(3):695-701. DOI: 10.1111/ggi.12155
11. Steffl M, Bohannon RW, Sontakova L, Tufano JJ, Shiells K, Holmerova I. Relationship between sarcopenia and physical

activity in older people: a systematic review and meta-analysis. Clin Interv Aging 2017;12:835-45. DOI: 10.2147/cia. s132940

12. De Buyser SL, Petrovic M, Taes YE, Toye KR, Kaufman JM, Lapauw B, et al. Validation of the FNIH sarcopenia criteria and SOF frailty index as predictors of long-term mortality in ambulatory older men. Age Ageing 2016;45(5):603-8. DOI: 10.1093/ageing/afw071
13. Dhillon RJ, Hasni S. Pathogenesis and Management of Sarcopenia. Clinics Geriatric Medicine 2017;33(1):17-26. DOI: 10.1016/j.cger.2016.08.002
14. Yuan S, Larsson SC. Epidemiology of sarcopenia: Prevalence, risk factors, and consequences. Metabolism 2023;144:155533. DOI: 10.1016/j.metabol.2023.155533.
15. Eglseer D, Eminovic S, Lohrmann C. Association between sarcopenia and nutritional status in older adults: a systematic literature review. J Gerontol Nurs 2016;42:33-41. DOI: 10.3928/00989134-20160613-03
16. Guigoz Y, Lauque S, Vellas BJ. Identifying the elderly at risk for malnutrition. The Mini Nutritional Assessment. Clin Geriatr Med 2002;18(4):737-57. DOI: 10.1016/s0749-0690(02)00059-9.
17. Yürüyen M, Yavuzer H, Yavuzer S, Cengiz M, Demirdağ F, Kara Z, et al. Comparison of nutritional risk screening tools for predicting sarcopenia in hospitalized patients. Turkish Journal of Medical Sciences 2017;47:1362-9 DOI: 10.3906/sag-1702-43
18. Zhang X, Zhang Z, Zhu Y, Tao J, Zhang Y, Wang Y, et al. Comparison of the efficacy of Nutritional Risk Screening 2002 and Mini Nutritional Assessment Short Form in recognizing sarcopenia and predicting its mortality. Eur J Clin Nutr 2020;74(7):1029-37. DOI: 10.1038/s41430-020-0621-8
19. Vellas B, Villars H, Abellan G, Soto ME, Rolland Y, Guigoz Y, et al. Overview of the MNA--Its history and challenges. J Nutr Health

Aging 2006;10(6):456-63.

20. Rubenstein LZ, Harker JO, Salvà A, Guigoz Y, Vellas B. Screening for undernutrition in geriatric practice: developing the short-form mini-nutritional assessment (MNA-SF). J Gerontol A Biol Sci Med Sci 2001;56(6):M366-72. DOI: 10.1093/gerona/56.6.m366
21. Roberts HC, Denison HJ, Martin HJ, Patel HP, Syddall H, Cooper C, et al. A review of the measurement of grip strength in clinical and epidemiological studies: towards a standardized approach. Age Ageing 2011;40(4):423-9. DOI: 10.1093/ageing/afr051
22. Kawakami R, Miyachi M, Tanisawa K, Ito T, Usui C, Midorikawa T, et al. Development and validation of a simple anthropometric equation to predict appendicular skeletal muscle mass. Clin Nutr 2021;40(11):5523-30. DOI: 10.1016/j.clnu.2021.09.032
23. Zhu X, Dong X, Wang L, Lao X, Li S, Wu H. Screening efficacy of PhA and MNA-SF in different stages of sarcopenia in the older adults in community. BMC Geriatr 2023;23(1):13. DOI: 10.1186/s12877-022-03716-x
24. Cederholm T, Jensen GL, Correia MITD, Gonzalez MC, Fukushima R, Higashiguchi T, et al. GLIM Core Leadership Committee; GLIM Working Group. GLIM criteria for the diagnosis of malnutrition - A consensus report from the global clinical nutrition community. Clin Nutr 2019;38(1):1-9. DOI: 10.1016/j.clnu.2018.08.002
25. Tamura BK, Bell CL, Masaki KH, Amella EJ. Factors associated with weight loss, low BMI, and malnutrition among nursing home patients: a systematic review of the literature. J Am Med Dir Assoc 2013;14(9):649-55. DOI: 10.1016/j.jamda.2013.02.022
26. van den Berg GH, Huisman-de Waal GGJ, Vermeulen H, de van der Schueren MAE. Effects of nursing nutrition interventions on outcomes in malnourished hospital inpatients and nursing home

residents: A systematic review. Int J Nurs Stud 2021;117:103888. DOI: 10.1016/j.ijnurstu.2021.103888

27. Velázquez-Alva MC, Irigoyen-Camacho ME, Cabrer-Rosales MF, Lazarevich I, Arrieta-Cruz I, Gutiérrez-Juárez R, et al. Prevalence of Malnutrition and Depression in Older Adults Living in Nursing Homes in Mexico City. Nutrients 2020;12(8):2429. DOI: 10.3390/nu12082429

Table I. Descriptive results of the study sample

	Mean (SD)	**Rank**
Age, years	69.75 (5.51)	54.00-89.00
Body composition		
Weight, kg	68.19 (11.57)	32.70-103.00
Height, cm	156.37 (7.45)	136.00-174.00
BMI	27.87 4.26)	15.76-40.53
Arm circumference, cm	29.93 (3.76)	20.47-43.83
Waist circumference, cm	96.75 (9.92)	67.83-128.33
Calf circumference, cm	34.73 (3.31)	25.87-49.50
Calf fold, mm	17.60 (6.41)	4.67-50.00
Fat, %	31.82 (7.94)	9.30-47.90
MNA-SF, score	12.17 (1.78)	4.00-14.00
MNA-LF, score	25.13 (2.83)	9.50-30.00

BMI: body mass index; MNA-SF: Mini-Nutritional Assessment short form; MNA-LF: Mini-Nutritional Assessment long form.

Table II. Data on age, body composition, strength, mass, and muscle performance between the MNA-SF categories						
	MNA-SF: 12-14 points n = 106		**MNA-SF: 8-11 points n = 55**		**MNA-SF: 0-7 points n = 1**	
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**
Age, years	69.13	4.90	70.73	6.30	81.00	-
Body composition						
Weight, kg	68.80	10.60	67.38	13.07	47.10	-
Height, cm	156.05	7.18	157.13	7.97	149.00	-
BMI	28.25	3.81	27.26	4.94	21.22	-
Arm circumference, cm	30.16	3.46	29.59	4.25	24.37	-
Waist circumference, cm	97.15	9.73	96.39	9.97	74.30	-
Calf circumference, cm	34.95	3.18	34.38	3.52	30.07	-
Calf fold, mm	18.24	6.60	16.44	5.93	13.33	-
Fat, %	32.28	7.51	31.12	8.66	20.60	-
Muscular strength						
Dynamometry	20.43	6.35	19.31	6.83	9.43	
Muscle mass						
ASMM, kg	17.39	3.79	17.30	4.50	11.78	-
ASMM/height^2	7.08	1.10	6.94	1.48	5.31	-

Muscle function						
Run time, seconds	4.08	1.31	4.18	1.42	5.00	-
Walking speed, m/s	1.02	0.33	1.05	0.35	1.25	-
MNA-SF, score	13.24	0.85	10.25	0.95	4.00	-
MNA-LF, score	26.34	1.98	23.08	2.15	9.50	-

BMI: body mass index; ASMM: appendicular skeletal muscle mass; MNA-SF: Mini-Nutritional Assessment short form; MNA-LF: Mini-Nutritional Assessment long form.

Table III. Data on age, body composition, strength, mass, and muscle performance between the MNA-LF categories

	MNA-LF: 24-30 points n = 119		**MNA-LF: 17-23.5 points n = 42**		**MNA-LF: 0-16 points n = 1**	
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**
Age, years	69.11	5.13	71.29	6.06	81.00	-
Body composition						
Weight, kg	68.42	10.16	68.02	14.75	47.10	-
Height, cm	156.69	7.31	155.64	7.90	149.00	-
BMI	27.88	3.70	28.00	5.54	21.22	-
Arm circumference, cm	30.15	3.40	29.43	4.61	24.37	
Waist circumference, cm	96.76	9.66	97.26	10.25	74.30	-
Calf circumference, cm	34.87	3.05	34.42	3.95	30.07	-
Calf fold, mm	17.73	6.56	17.35	6.07	13.33	-
Fat, %	31.78	7.49	32.18	9.08	20.60	-
Muscular strength						
Dynamometry	20.44	6.18	19.75	6.84	9.43	-
Muscle mass						
ASMM, kg	17.47	3.64	17.06	5.01	11.78	-
ASMM/height^2	7.06	1.03	6.96	1.72	5.31	-
Muscle function						
Run time, seconds	4.13	1.43	4.07	1.07	5.00	-

Walking speed, m/s	1.03	0.36	1.02	0.27	1.25	-
MNA-SF, score	13.5	12-14	11	10.0-11.0	4.00	-
MNA-LF, score	26.5	25-27.5	23.5	22.0-24.5	9.50	-

BMI: body mass index; ASMM: appendicular skeletal muscle mass; MNA-SF: Mini-Nutritional Assessment short form; MNA-LF: Minimal Nutritional Assessment long form.

Table IV. Results of the sensitivity and specificity of the MNA-SF and MNA-LF cut-off points for detecting sarcopenia and its components			
	Cut-off value	**Sensitivity (95 % CI)**	**Specificity (95 % CI)**
Sarcopenia			
MNA-SF	< 13	69.70 (52.66-82.62)	52.71 (44.14-61.13)
	< 12	54.55 (37.99-70.16)	70.54 (62.17-77.72)
MNA-LF	< 25.5	69.70 (52.66-82.62)	49.61 (41.12-58.13)
	< 24	36.36 (22.19-53.38)	75.97 (67.91-82.52)
Low muscle strength			
MNA-SF	< 13	56.14 (46.98-64.90)	58.33 (44.28-71.15)
	< 12	39.47 (30.98-48.65)	77.08 (63.46-86.69)
MNA-LF	< 25.5	63.16 (54.01-71.45)	66.67 (52.54-78.32)
	< 24	28.07 (20.64-36.93)	77.08 (63.46-86.69)
Low muscle mass			
MNA-SF	< 13	69.70 (52.70-82.62)	52.71 (44.14-61.13)
	< 12	54.55 (37.99-70.16)	70.54 (62.17-77.72)
MNA-LF	< 25.5	69.70 (52.66-	49.61 (41.12-

		82.62)	58.13)
	< 24	36.36 (22.19-53.38)	75.97 (67.91-82.52)
Low muscle performance			
MNA-SF	< 13	54.55 (41.52-66.97)	55.14 (45.70-64.22)
	< 12	69.09 (55.97-79.72)	36.45 (27.95-45.89)
MNA-LF	< 25.5	52.73 (39.79-65.31)	57.94 (48.47-66.86)
	< 24	81.82 (69.67-89.81)	30.84 (22.88-40.13)
MNA-SF: Mini-Nutritional Assessment short form; MNA-LF: Mini-Nutritional Assessment long form.			

Table V. Logistic regression models for determining the probability of presenting sarcopenia, low strength, mass and muscle performance according to the MNA-SF and MNA-LF cut-off points						
	Crude model			**Adjusted model**		
	OR	**95 % CI**	**p value**	**OR**	**95 % CI**	**p value**
Model for sarcopenia						
MNA-SF < 13	2.56	1.13-5.82	0.02	2.36	1.02-5.45	0.04
MNA-SF < 12	2.87	1.31-6.29	0.008	2.47	1.10-5.54	0.03
MNA-LF < 25.5	1.83	0.84-3.98	0.13	1.51	0.67-3.40	0.32
MNA-LF < 24	1.81	0.80-4.09	0.16	1.51	0.65-3.54	0.34
Model for low muscle strength						
MNA-SF < 13	1.79	0.91-3.55	0.09	1.74	0.86-3.49	0.12
MNA-SF < 12	2.19	1.02-	0.04	1.95	0.89-	0.10

		4.74			4.28	
MNA-LF < 25.5	2.82	1.38-5.75	0.004	2.53	1.22-5.24	0.01
MNA-LF < 24	1.31	0.60-2.89	0.50	1.16	0.51-2.63	0.72
Model for low muscle mass						
MNA-SF < 13	2.56	1.13-5.82	0.02	2.36	1.02-5.45	0.04
MNA-SF < 12	2.87	1.31-6.29	0.008	2.47	1.10-5.54	0.03
MNA-LF < 25.5	1.83	0.84-3.98	0.13	1.51	0.67-3.40	0.32
MNA-LF < 24	1.81	0.80-4.09	1.16	1.51	0.65-3.53	0.34
Model for Low muscle performance						
MNA-SF < 13	0.68	0.35-1.30	0.24	0.67	0.33-1.34	0.26
MNA-SF < 12	0.78	0.39-1.56	0.48	0.74	0.35-1.56	0.43
MNA-LF < 25.5	0.73	0.38-	0.35	0.72	0.35-	0.36

		1.41			1.46	
MNA-LF < 24	0.49	0.22-1.11	0.09	0.53	0.23-1.24	0.14

OR: Odds ratio; 95 % CI: 95 % confidence interval; MNA-SF: Mini-Nutritional Assessment short form; MNA-LF: Mini-Nutritional Assessment long form. Adjusted model by age (Continuous) and sex.

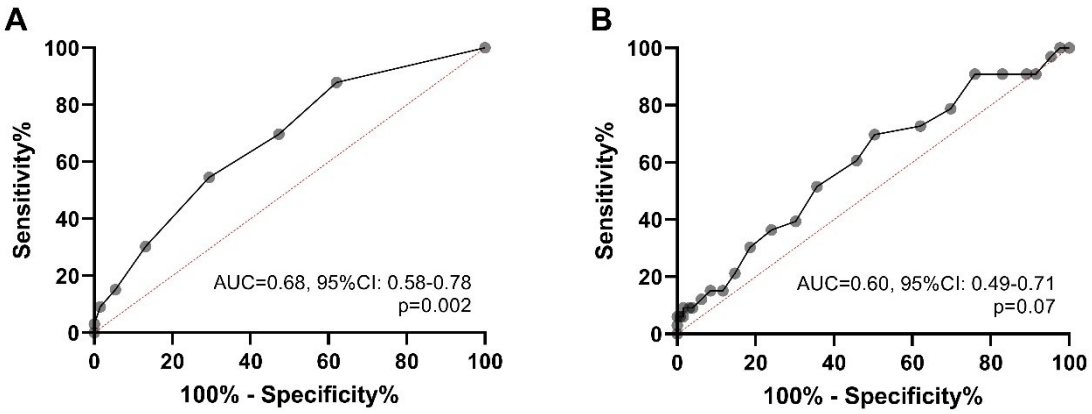

Figure 1. ROC curves for the detection of sarcopenia by the MNA-SF and MNA-LF scores. A. MNA-SF (Mini-Nutritional Assessment short form. B. MNA-LF (Mini-Nutritional Assessment long form).

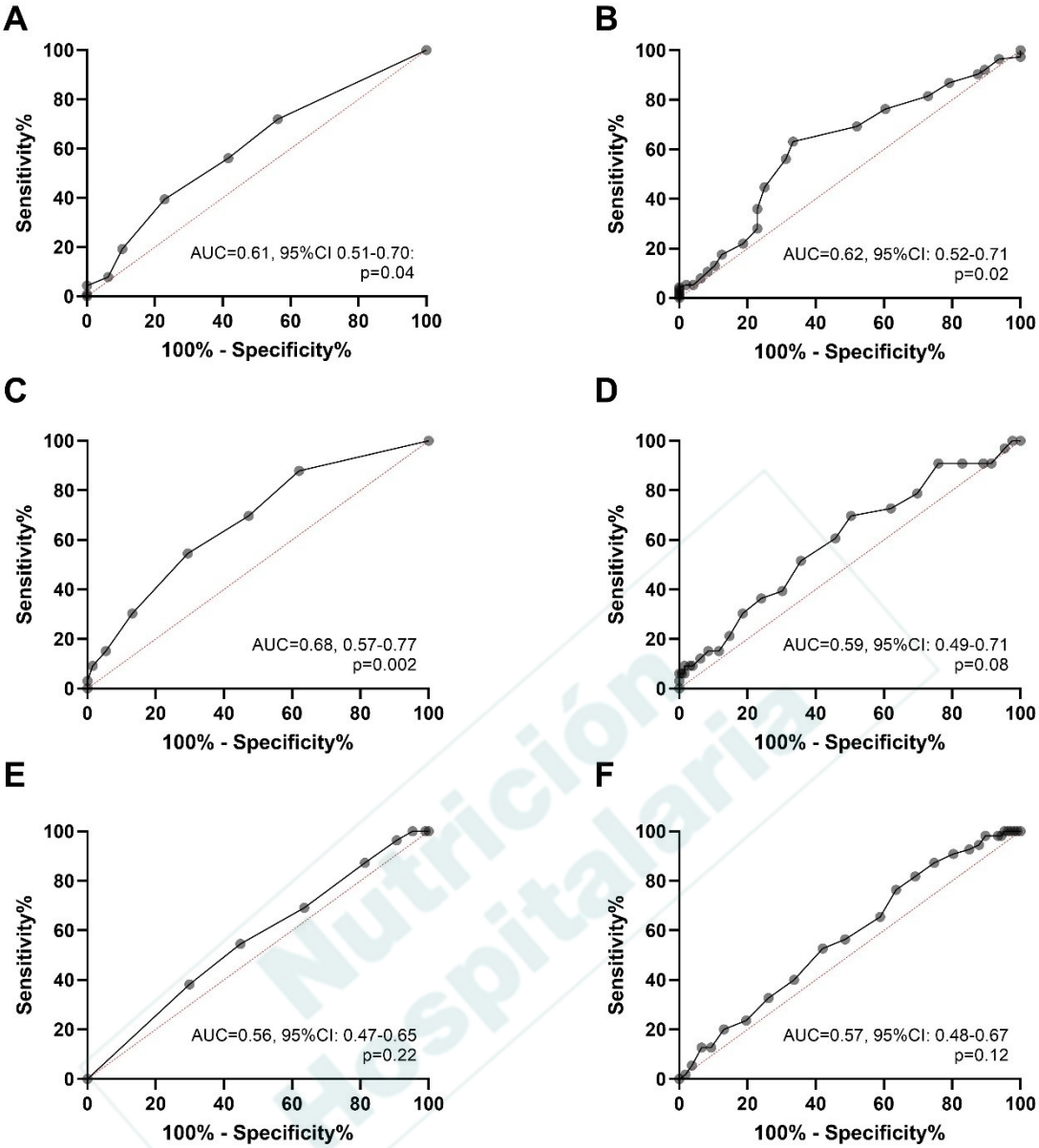

Figure 2. ROC curves for the detection of low muscle strength, mass and performance by the MNA-SF and MNA-LF scores. A. ROC curve to detect low muscle strength by the MNA-SF (Mini-Nutritional Assessment short form). B. ROC curve to detect low muscle strength by the MNA-LF (Mini-Nutritional Assessment long form). C. ROC curve for low detector muscle mass by the MNA-SF (Mini-Nutritional Assessment short form). D. ROC curve to detect low muscle strength by the MNA-LF (Mini-Nutritional Assessment long form). E. ROC curve to detect low

muscle performance by the MNA-SF (Mini-Nutritional Assessment short form). F. ROC curve to detect low muscle performance by the MNA-LF (Mini-Nutritional Assessment long form).