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ORIGINAL CONTRIBUTION

Neutrophil-to-lymphocyte ratio and lymphocyte count as an alternative to body mass index for screening malnutrition in older adults living in the community

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Abstract

Purpose Accurate height and weight measurement can be challenging in older adults and complicates nutritional status assessment. Other parameters like the neutrophil-to-lymphocyte ratio (NLR) and the lymphocyte count (LC) could be an option to these measurements. We aimed to test these variables as subrogates of body mass index (BMI) or calf-circumference (CC) for malnutrition screening in community-dwelling older adults.

Methods This is a secondary analysis from the Salud, Bienestar y Envejecimiento (SABE) survey from Ecuador (2009). Includes data on demographics, health-related factors, physical assessments, and complete blood count, allowing to calculate NLR and LC to be used as part of the Mini Nutritional Assessment (MNA), instead of the BMI. Consequently, 4 models were included: standard MNA, MNA-CC, MNA-NLR and MNA-LC. Finally, age, sex, and comorbidities were considered as confounding variables.

Results In our analysis of 1,663 subjects, 50.81% were women. Positive correlations with standard MNA were found for MNA-NLR (Estimate = 0.654, $p < 0.001$) MNA-CC (Estimate = 0.875, p value < 0.001) and MNA-LC (Estimate = 0.679, $p < 0.001$). Bland-Altman plots showed the smallest bias in MNA-CC. Linear association models revealed varying associations between MNA variants and different parameters, being MNA-NLR strongly associated with all of them (e.g. Estimate = 0.014, $p = 0.001$ for albumin), except BMI.

Conclusion The newly proposed model classified a greater number of subjects at risk of malnutrition and fewer with normal nutrition compared to the standard MNA. Additionally, it demonstrated a *strong* correlation and concordance with the standard MNA. This suggests that hematological parameters may offer an accurate alternative and important insights into malnutrition.

Keywords Nutritional status · Neutrophils · Lymphocytes · Body mass index · Geriatric assessment · Mini-nutritional assessment

Introduction

Due to the increasing prevalence of older individuals in our population, healthy ageing promotion has emerged as a public health concern [1]. As a result, one pivotal facet of this promotion is the maintenance of optimal nutritional status [2]. Substantiated evidence underscores the significant impact of malnutrition and weight loss on various aspects of well-being in the older adult population [3], including their functional capacity, quality of life, frailty risk, and overall mortality [4].

Nutritional status is an essential part in the geriatric evaluation [2]. The Mini Nutritional Assessment (MNA) is one of the most used tools for screening malnutrition and was

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developed to identify individuals at risk of malnutrition or already malnourished. The MNA is designed to help health professionals (i.e., doctors, nurses, dietitians, etc.) to assess and monitor the nutritional health of older people [5].

The MNA consists of a series of questions and measurements (anthropometry) related to various aspects of nutrition, health, and functionality [5]. However, the key parameters employed in this assessment tool may not always be readily available. In particular, the reliability of BMI can often be compromised due to factors such as kyphosis, changes in height over time, vertebral compression fractures, and other conditions. Additionally, it is frequently challenging to obtain accurate height and weight measurements for calculating BMI in situations where mobility is limited. This has prompted a growing research focus on exploring alternative biomarkers [6], including calf-circumference (CC) as an effective alternative to replace BMI in the MNA [7].

The neutrophil-to-lymphocyte ratio (NLR) stands as a promising hematological parameter, providing valuable insights into the presence of systemic inflammation and a reflection of catabolic status. What makes NLR particularly advantageous is its wide availability as part of a routine complete blood count (CBC), ensuring that it can be easily and routinely assessed in all individuals [8, 9].

This versatile parameter has expanded beyond its initial role as an inflammation marker to find broader application in healthcare, especially in assessing nutritional status. This expansion is driven by the observed link between low-grade systemic inflammation and malnutrition. Notably, people grappling with malnutrition tend to exhibit a distinctive pattern where their NLR levels are significantly elevated compared to individuals with a normal nutritional status, with a significant negative correlation between NLR and the MNA score (r = -0.276, p = 0.007), and a correlation with nutritional status indicators such as albumin level, BMI and CC [10]. NLR may serve as a readily accessible biomarker for identifying and monitoring individuals at risk of or experiencing malnutrition, and an alternative when anthropometrical measures are not feasible, or its reliability is compromised.

Nutritional screening should be conducted in every geriatric care setting as an integral component of the comprehensive geriatric assessment, regardless of the circumstances. Therefore, alternative measures to BMI should be explored and discussed. As such, our objective is to test NLR and Lymphocyte Count (LC) as subrogates of BMI or CC for malnutrition screening in community-dwelling older adults.

Methods

The analysis utilized data from the SABE-Ecuador (Salud, Bienestar y Envejecimiento) study conducted between June and August of 2009. The inclusion criteria were as follows: community-dwelling 60-year or older adults, residing in either rural or urban areas of Ecuador. On the other hand, exclusion criteria included: individuals unable to provide informed consent, individuals living into collective dwellings and economic establishments. A total of 5,235 participants were assessed [11]. It is derived from the international survey designed for the original SABE study conducted in five Latin American capital cities. In this survey, probabilistic sampling was employed as the sampling methodology. A total of 10,368 households were surveyed, with 85.8% of subjects having a complete dataset and were included in the subsequent analysis [12, 13]. Data for anthropometrics and blood were available in a subgroup; therefore, the final sample was consisted in 1,663 participants. People finally included in our paper analysis are stipulated in Online Resource 1.

Variables

Neutrophils and lymphocytes

A CBC was measured in all individuals. Lymphocytes and neutrophils were obtained using automated hematology analyzes. Absolute counts were used, indicating each type of white blood cell per microliter (μL) of blood reported as cells/μL. Results from blood analysis have been previously reported [14], and the deidentified results of the survey are publicly available at http://www.ecuadorencifras.gob.ec/encuesta-de-salud-bienestar-del-adulto-mayor/.

NLR was calculated by dividing the absolute neutrophil count by the absolute lymphocyte count [8].

We abstracted cut points based on quartiles (Online Resource 2). For NLR < 1.098 = 3 points, 1.098–1.456 = 2 point, 1.456–1.897 = 1 points and > 1.897 = 0 points. For LC < 1892 = 0 points, 1892–2333 = 1 point, 2333–2830 = 2 points and > 2830 = 3 points.

Body mass index

Body weight and height were measured with the patient wearing light clothing. BMI was calculated using Quetelet's index. Based on the result, four categories were stablished: <18.5 kg/m^2 underweight, 18.5–24.9 kg/m^2 normal, 25–29.9 kg/m^2 overweight, > 30 kg/m^2 obese [15, 16].

Calf circumference

Ensuring the person is standing with feet flat on the ground, a flexible tape measure around the widest part of the calf was done to determine CC. The tape was snug but not too tight, parallel to the ground. Measurement was recorded in centimeters after taking it three times for accuracy. For this study we used the first measurement. We then defined MNA-CC, which has been previously reported in the literature [7].

Nutritional status

The short version of the MNA was performed in all participants. MNA score was used as a continuous variable, but also as a categoric one. MNA score between 12 and 14 points was categorized as 'normal nutritional status', a score of 8–11 points was considered as 'at risk of malnutrition' and a score between 0 and 7 points classifies the patient as 'malnourished' [17].

Other variables

We included additional variables to stablish their association with each MNA model. Albumin was part of blood analysis reported in grams per deciliters (g/dL). Activities of Daily Living (ADLs) were included using the Lawton score [18]. Additionally, handgrip strength in kilograms (kg) was established using a hydraulic hand dynamometer with the dominant hand. Five Times Sit-to-Stand Test, the Romberg Test while standing with feet together, and the one-legged stance test were measured in seconds [19]. Finally, cognition was measured using the abbreviated version of the Mini-Mental State examination (MMSE), which has been previously used and validated in other SABE surveys [20].

We included age, sex, years of education and medical conditions index in our analysis to adjust the proposed models. We assessed the presence of comorbidities, including diabetes mellitus, depression, chronic obstructive pulmonary disease (COPD), joint disorders, osteoporosis, cancer, cerebrovascular events, visual problems, and heart disease, through self-report from patients or their families. These variables were summed to generate a comorbidity index.

Statistical analysis

First, we conducted an exploratory data analysis to detect outliers and atypical data. Subsequently, frequencies were calculated for categorical variables, and means along with their respective standard deviations were estimated for continuous variables. Following that, a group comparison analysis was performed to assess gender differences regarding the variables included in the study. For categorical variables, Pearson's chi-square test was employed, while for continuous variables, Student's t-test was used. Following this, a correlation analysis was conducted using Spearman's Rho coefficient among the different MNA variations (MNA original, MNA-CC, MNA-NLR, and MNA-LC). Additionally, Kappa statistics was performed to compare the concordance between the categories of the traditional MNA with the different approaches of MNA. Also, Bland-Altman plots were constructed to evaluate and communicate the concordance and differences between the various MNA approaches, including the mean of the differences, the bias and individual observations. Finally, linear regression models were fitted to explore the association of the different MNA approaches as exposure variables with each of the outcomes of interest: BMI (kg/m^2), MMSE, Albumin (g/dL), IADLs, Handgrip strength (kg), Calf circumference (cm), Five Times Sit to Stand Test (seconds), Romberg Test stands with feet together (seconds), and One-legged stance test (seconds). These models were adjusted for sex, age, years of schooling, and comorbidities. During the diagnostic phase of the adjusted models, observations considered as outliers were removed using Cook's Distance. A significance level of 0.05 was set for hypothesis testing. R software version 4.2.1 was used to carry out the statistical analyses.

Results

We included 1,663 subjects in our analysis (for complete descriptive information see Table 1). When using the standard MNA with the BMI, 71.3% ($n=1,186$) of the population had a normal nutritional status. MNA-CC classified 71.4% ($n=1,187$) of the population with a normal nutritional status. However, when using MNA-NLR or MNA-LC, this percentage diminished to 39.4% ($n=656$) and 40.7% ($n=677$), respectively. Therefore, proportion of people at risk of malnutrition (57.2% and 56.0%) and malnourished (3.3% and 3.2%) was larger using the MNA-NLR and MNA-LC, respectively, compared to the BMI approach (28% at risk of malnutrition and 0.7% malnourished). Medians in the new proposed models are equal, and smallest compared to the standard approach by 1 point in all groups (Table 2). We conducted Kappa statistics to compare the original MNA with MNA-NRL and MNA-LC. Here, the MNA-NLR (0.310) and MNA-LC (0.337) demonstrated fair agreement with the original MNA, while the MNA-CC (0.748) showed substantial agreement, as demonstrated in Online Resource 3 [21].

For the standard form of the MNA, we found a positive correlation for MNA-NLR (Estimate = 0.654, p-value < 0.001) and MNA-LC (Estimate = 0.679, p-value < 0.001). The

Table 1 Population characteristics

Characteristics	Females ($n=845$)	Males ($n=818$)	Overall ($n=1663$)	P-value **
Age, mean (SD)	69.9 (7.70)	70.0 (7.76)	69.9 (7.73)	0.688
Years of education, mean (SD)	3.38 (4.70)	3.23 (0.970)	3.31 (3.42)	0.387
BMI (kg/m2), mean (SD)	27.4 (4.89)	25.3 (3.86)	26.4 (4.53)	< 0.001
BMI categorize (kg/m2), (%) *				
Under weight	19 (2.2%)	19 (2.3%)	38 (2.3%)	< 0.001
Normal	249 (29.5%)	375 (45.8%)	624 (37.5%)	
Overweight	352 (41.7%)	335 (41.0%)	687 (41.3%)	
Obese	225 (26.6%)	89 (10.9%)	314 (18.9%)	
Albumin (g/dL)	4.37 (0.308)	4.36 (0.323)	4.36 (0.315)	0.834
Lymphocytes (cells/µL), mean (SD)	2450 (768)	2390 (773)	2420 (771)	0.082
Neutrophils (cells/µL), mean (SD)	3470 (1300)	3720 (1460)	3590 (1390)	< 0.001
Neutrophil-to-lymphocyte ratio (NLR), mean (SD)	1.54 (0.860)	1.71 (0.869)	1.62 (0.868)	< 0.001
Calf circumference (Cm), mean (SD)	34.6 (4.05)	34.9 (3.57)	34.8 (3.82)	0.181
Mini Nutritional Assessment (MNA), mean (SD)	12.1 (1.52)	12.1 (1.61)	12.1 (1.57)	0.624
Mini mental State Examination (MMSE), mean (SD)	15.3 (3.02)	15.6 (2.81)	15.5 (2.92)	0.018
Instrumental Activity of Daily Living (IADLs), mean (SD)	8.09 (7.50)	6.55 (7.02)	7.41 (7.32)	0.113
Handgrip strength (Kg), mean (SD)	18.4 (5.86)	29.6 (8.45)	23.9 (9.16)	< 0.001
Number of comorbidities, mean (SD)	1.96 (1.52)	1.19 (1.31)	1.58 (1.47)	< 0.001
Five Times Sit to Stand Test (seconds), mean (SD)	15.0 (13.8)	12.9 (10.8)	13.9 (12.4)	< 0.001
Romberg Test, stands with feet together (seconds), mean (SD)	10.5 (6.77)	10.4 (6.06)	10.5 (6.42)	0.713
One-legged stance test (seconds), mean (SD)	17.3 (25.4)	13.9 (19.1)	15.6 (22.5)	0.002

** Differences between groups (sex)

Table 2 Nutritional status of the sample based on the different MNA models divided by sex

Characteristics	Females ($n=845$)	Males ($n=818$)	Overall ($n=1663$)	
Mini Nutritional Assessment (MNA) Categorize, (%)				
Normal nutritional status	606 (71.7%)	580 (70.9%)	1186 (71.3%)	0.289
At risk of malnutrition	236 (27.9%)	230 (28.1%)	466 (28.0%)	
Malnourished	3 (0.4%)	8 (1.0%)	11 (0.7%)	
Mini Nutritional Assessment (MNA) categorize, NLR approach, (%)				
Mini Nutritional Assessment (MNA), NLR approach, mean (SD)	11.0 (1.75)	11.0 (1.75)	11.0 (1.76)	0.129
Normal nutritional status	358 (42.4%)	298 (36.4%)	656 (39.4%)	0.043
At risk of malnutrition	459 (54.3%)	493 (60.3%)	952 (57.2%)	
Malnourished	28 (3.3%)	27 (3.3%)	55 (3.3%)	
Mini Nutritional Assessment (MNA) Lymphocytes approach, (%)				
Mini Nutritional Assessment (MNA) categorize, Lymphocytes approach, mean (SD)	11.0 (1.74)	11.0 (1.79)	11.0 (1.77)	0.654
Normal nutritional status	338 (40.0%)	339 (41.4%)	677 (40.7%)	0.834
At risk of malnutrition	479 (56.7%)	453 (55.4%)	932 (56.0%)	
Malnourished	28 (3.3%)	26 (3.2%)	54 (3.2%)	
Mini Nutritional Assessment (MNA) Calf circumference approach, (%)				
Mini Nutritional Assessment (MNA) Calf circumference approach, mean (SD)	11.9 (1.86)	12.2 (1.72)	12.1 (1.80)	0.001
Normal nutritional status	580 (68.6%)	607 (74.2%)	1187 (71.4%)	0.038
At risk of malnutrition	243 (28.8%)	196 (24.0%)	439 (26.4%)	
Malnourished	22 (2.6%)	15 (1.8%)	37 (2.2%)	

** Differences between groups (sex)

highest correlation was found with the MNA-CC (Estimate = 0.875, p-value < 0.001) (Table 3). Also, a positive correlation between the LC and the NLR approaches was described (Fig. 1).

Related to concordance between models, Bland-Altman plots are presented in Fig. 2. When comparing to the traditional MNA, smallest bias was found on the MNA-CC (0.04), but performance was similar in the hematological based models (Fig. 2).

Table 3 Correlation models between MNA variants

Variables	Spearman's Rho					
	General		Males		Females	
	Estimation	P-value	Estimation	P-value	Estimation	P-value
MNA & MNA NLR approach	0.654	< 0.001	0.635	< 0.001	0.676	< 0.001
MNA & MNA Calf circumference approach	0.875	< 0.001	0.871	< 0.001	0.885	< 0.001
MNA & MNA Lymphocytes approach	0.679	< 0.001	0.668	< 0.001	0.691	< 0.001
MNA NLR approach & MNA LC approach	0.786	< 0.001	0.791	< 0.001	0.785	< 0.001

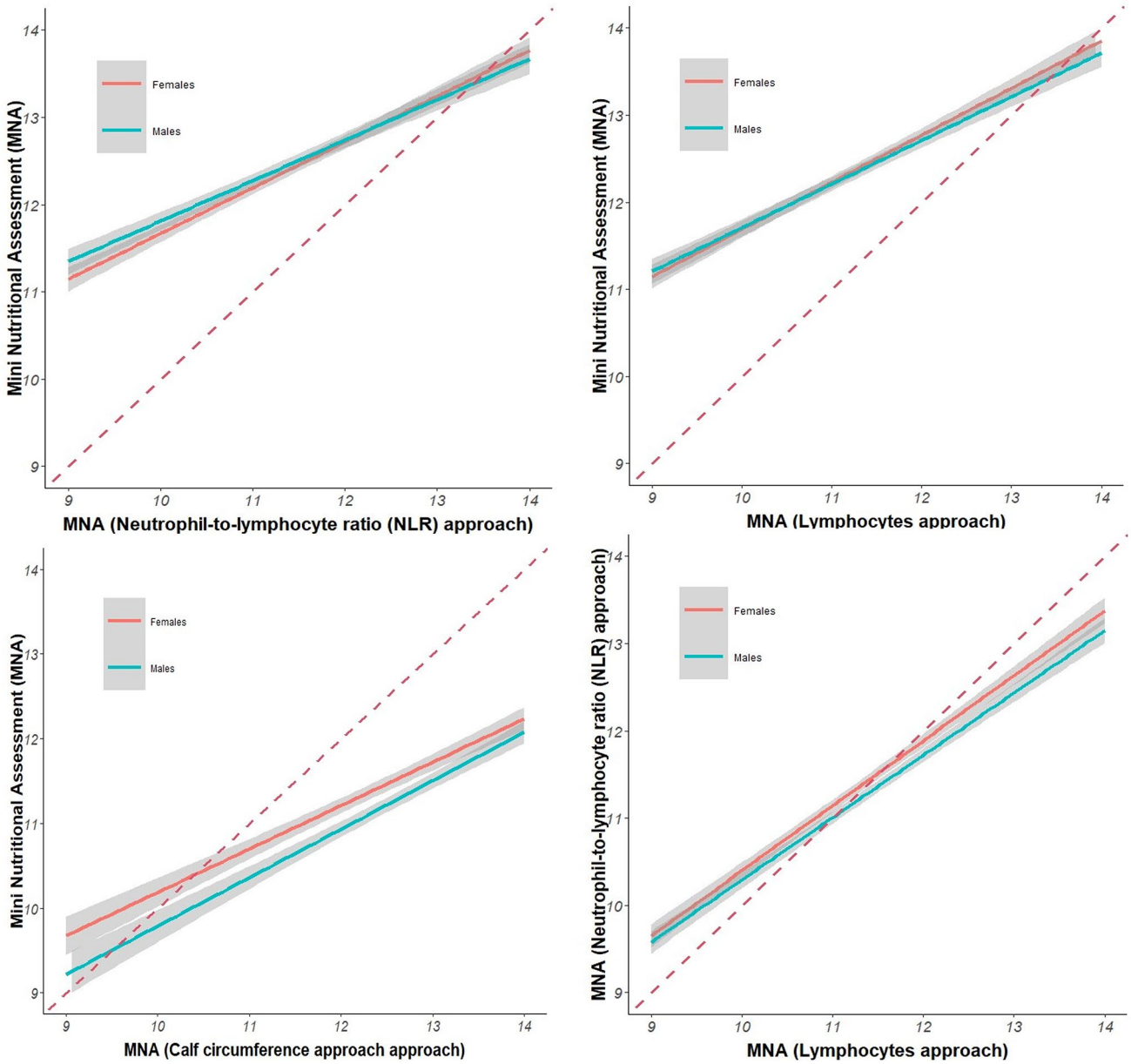


Fig. 1 Correlation models between MNA variants. *Note* Fig. 1 shows the correlation between the proposed approaches of the MNA for males and females. The dashed red line at 45 degrees indicates a 1:1 relationship between these different approaches. The deviation of the trend lines for males and females indicates how disparate or similar the different MNA approaches can be

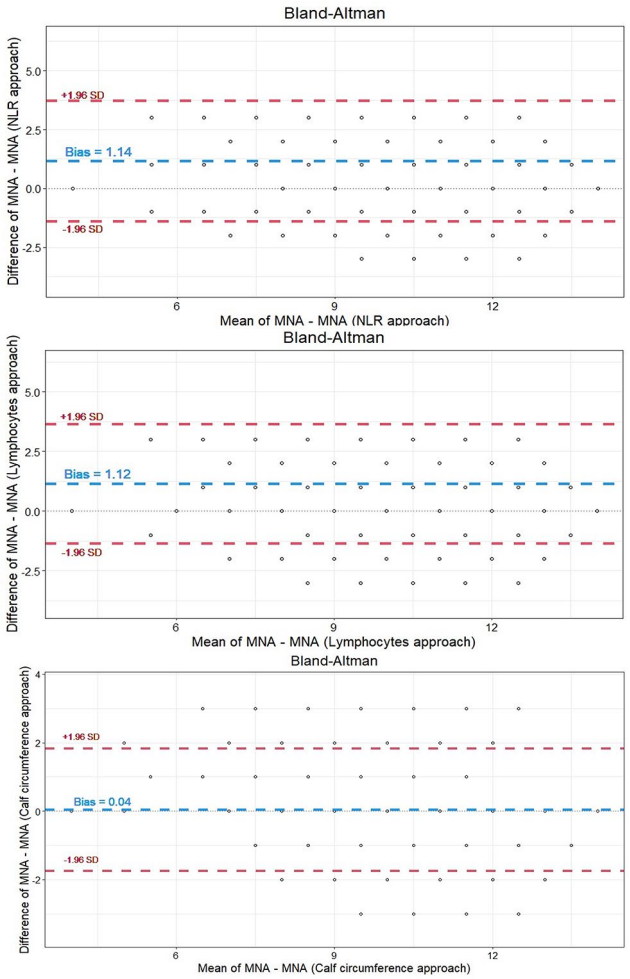


Fig. 2 Calf-circumference approach and new proposed models' concordance and performance compared to the standard MNA. *Note* Bland-Altman plots compare the concordance between different MNA approaches. The X-axis displays the mean of the differences between the approaches, while the Y-axis shows the difference between them. The dashed blue line represents the bias between the measurements, whereas the dashed red lines represent the limits of agreement (+1.96 SD and −1.96 SD). The points on the plot represent individual observations

Linear regression association models are presented in Table 4. Direction of the association was the same in all MNA variants as independent variables, and most of them were associated with most of the outcomes. Traditional MNA did not have association with one-legged stance test. MNA-LC did not associate with handgrip strength. MNA-NLR approach had the higher association with albumin (Estimate = 0.014, p value = 0.001). Figure 3 shows correlations between each model and predicted values for albumin.

Table 4 Linear association models between nutritional and physical related parameters with the different MNA approaches

Dependent variable	Exposure variables *											
	Mini Nutritional Assessment (MNA)			MNA (Neutrophil-to-Lymphocyte Ratio approach)			MNA (Lymphocytes approach)			MNA (Calf circumference approach)		
	Estimate	Std. Error	P value	Estimate	Std. Error	P value	Estimate	Std. Error	P value	Estimate	Std. Error	P value
BMI (kg/m2)	1.0181	0.0671	**< 0.001**	0.0721	0.0629	0.252	0.2259	0.0626	**< 0.001**	0.6994	0.0608	**< 0.001**
Mini mental State Examination (MMSE)	0.4648	0.0430	**< 0.001**	0.2815	0.0383	**< 0.001**	0.3317	0.0379	**< 0.001**	0.4705	0.0382	**< 0.001**
Albumin (g/dL)	0.0111	0.0050	**0.027**	0.0142	0.0044	**0.001**	0.0102	0.0044	**0.020**	0.0089	0.0045	**0.046**
Instrumental Activity of Daily Living (IADLs)	-1.0580	0.2844	**< 0.001**	-0.5275	0.2560	**0.041**	-0.4914	0.2461	**0.047**	-0.7292	0.2333	**0.002**
Handgrip strength (Kg)	0.3763	0.1046	**< 0.001**	0.2428	0.0927	**0.009**	0.1736	0.0974	0.075	0.5221	0.0968	**< 0.001**
Calf circumference (Cm)	0.7155	0.0583	**< 0.001**	0.1490	0.0534	**0.005**	0.1776	0.0533	**0.001**	0.8452	0.0495	**< 0.001**
Five Times Sit to Stand Test (seconds)	-0.5734	0.2150	**0.008**	-0.8307	0.1847	**< 0.001**	-0.6482	0.1850	**< 0.001**	-0.7716	0.1895	**< 0.001**
Romberg Test, stands with feet together (seconds)	-0.2680	0.1086	**0.014**	-0.2168	0.0954	**0.023**	-0.2819	0.0955	**0.003**	-0.3024	0.0959	**0.002**
One-legged stance test (seconds)	-0.4849	0.3668	0.186	-1.0103	0.3203	**0.002**	-0.6528	0.3220	**0.043**	-0.8495	0.3238	**0.009**

* Adjusted with sex, age, years of schooling and comorbidities

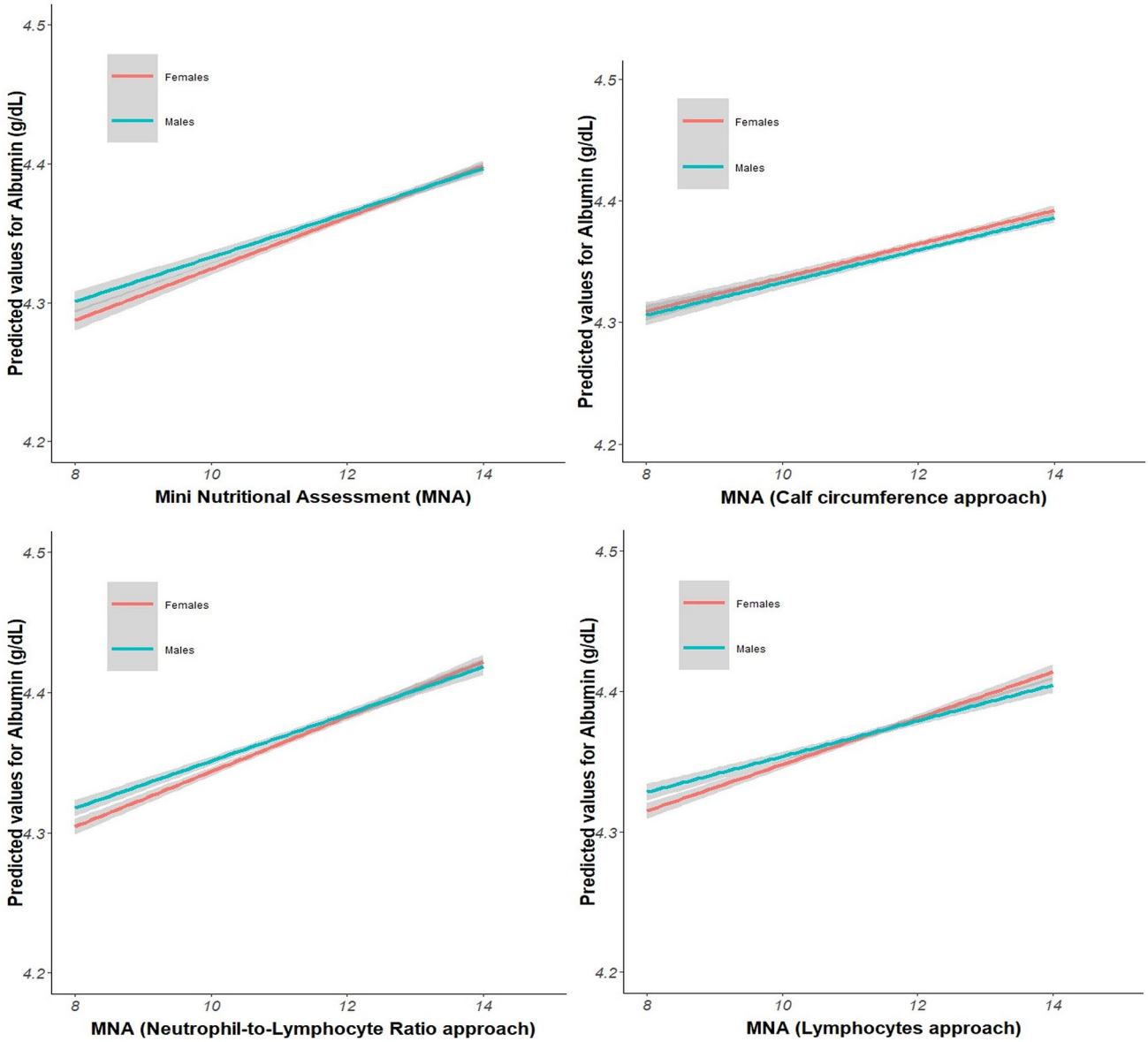


Fig. 3 Correlation of each model with albumin concentration. *Note* Fig. 3 shows correlation models between each MNA variant and albumin concentration. Fitted values with confidence intervals shows the association, with a different deviation of the trend lines for men and women

Discussion

In this study, we evaluated an alternative way of employing MNA to screen for malnutrition, replacing BMI, for NLR and the LC. The modified scales showed a strong correlation with the standard MNA, and a greater association with albumin and mental and physical variables studied in the models. These results present a novel contribution as we introduce hematological parameters into a widely used instrument in clinical settings: the MNA. Complementing prior studies that substituted BMI with anthropometric measures like CC or mid-arm circumference [7], we propose that NLR could serve as an effective and practical alternative. MNA-NLR was especially highly correlated with blood markers of nutrition, such as albumin, and well correlated to geriatric physical measures of health. Interestingly, the lack of statistical significance observed between MNA-NLR approach and BMI prompts a reconsideration of the intricate interplay between nutritional status and body composition in older adults.

In previous studies, BMI has been replaced in the MNA. In 2010, Tsai et al. [7] replaced this anthropometric variable for CC and mid-arm circumference and showed that this variant can effectively predict nutritional status in patients from Taiwan that were 65 years or older and without acute comorbidities. A complete examination was performed, and

blood samples were taken, as well as mid-arm, calf, hip, and waist circumferences based on standard protocol. A structured questionnaire was done to acquire data related to personal information, lifestyle-related factors and to respond the questions in the MNA. In that study, the same proportion of people was classified as malnourished with all the MNA variants. However, less participants were classified as at risk of malnutrition. In our results the proportion of people at risk of malnutrition was largest with MNA-NLR and MNA-LC compared to the classic MNA. This difference could be explained because these hematological parameters have a different relation with malnutrition compared to anthropometric measures and could be more sensible at detecting individuals at risk. Also, mid-arm circumference and CC may have a different diagnostic performance depending on functional status. Whereas CC is better in early stages, mid-arm circumference has shown a better correlation with people in late stages of functional decline [22].

Results using these anthropometrical variables as a replacement for BMI have been tested in other papers, finding similar performance, and proving them as a useful alternative [23]. Moreover, a study directly compared three different versions: the standard MNA, a 'proportional' MNA, where the total score is replaced by a ratio that considers the maximum score that a patient could obtain without the BMI, and the described version with CC and mid-arm circumference. Both versions had a good predictive value compared to the standard MNA and had similar results in the classification of subjects. Also, the authors stated that the modified versions could be more effective in detecting subjects with risk factors related to malnutrition such as hand grip strength and disability [24]. Alternately, using blood substitutes of BMI in older adults might be useful in cases where anthropometric substitutes are not technically feasible or may not comprehensively address the challenges associated with physical changes and common pathologies in older adults. For example, conditions like sarcopenic obesity, where the muscle is reduced but the calf might be surrounded by a significant amount of subcutaneous fat, or leg edema.

As mentioned, in this research, the classification between categories (normal, at risk, and malnutrition) differed, especially in the number of older adults detected as normal. This discrepancy was notable when comparing the MNA based on anthropometrics versus the MNA based on blood markers. Optimal cutoff points for the blood biomarkers have not been established yet, and this can alter the classification; still, we determined the NLR and LC cut points using division by quartiles.

When testing agreement in the malnutrition category classification using kappa, we found good agreement only with CC, while only fair agreement was observed with LC and NLR. This is likely because BMI and CC are derived from physical measurements, evidencing a closer relationship between them. Generally, discrepancies between similar instruments between categories might also reflect the difference in the cut-off values when using close tools (but not the same), also as a plausible explanation for our results.

These results indicate that blood markers identify a larger number of individuals at risk of malnutrition. Consequently, the increased classification of positive cases among individuals at risk of malnutrition leads to a higher number of false positives but a lower number of false negatives. This characteristic makes it more suitable for screening purposes. The high rate of malnutrition observed in individuals with elevated MNA-NLR and MNA-LC scores may be a result of the complex interplay between chronic inflammation, aging-related physiological changes, and the presence of comorbid diseases. Chronic inflammation, which is common older adults and increase with chronic comorbidity, can lead to physiological changes that affect nutritional status. One key aspect is the expression of specific cytokines [25]. These cytokines can impact the number and function of inflammatory cells such as neutrophils and lymphocytes, making them more objective markers of catabolic status compared to weight and height, which may be less reliable when assessing older adults. Moreover, the original tool might have a ceiling effect, evidenced by this change. Nevertheless, further studies are necessary, incorporating comprehensive nutritional assessments and longitudinal cohorts, to substantiate the validity of this proposal. Manly when is rational to think that obese people can be malnourished but at the same time have a good score in the MNA BMI section.

It is important to highlight that NLR is also related to other systemic diseases, which can affect the results. In general, this variable is a marker of systemic inflammation. It has been described that a rise in neutrophil count can be caused by bacterial or fungal infection, acute stroke, myocardial infarction, atherosclerosis, severe trauma, cancer, or post-surgery complications [9]. However, these are mostly acute diseases, which are not common in the setting of community dwelling adults included in the SABE survey. Possible confounders of the NLR are conditions such as age, obesity, active hematological disorder, type 2 diabetes, emotional stress, and human immunodeficiency virus. Nevertheless, these factors induce inflammation, modify the NLR, elevate catabolism, and thus potentially increase the risk of malnutrition [26].

When evaluating other tools to assess nutritional status, LC has been used as one of the variables. For example, The Controlling Nutritional Status (CONUT) tool includes LC, cholesterol, and serum albumin, and was developed for its use in hospitals settings [27]. However, it does not include clinical variables for nutritional status assessment. Other

tools like The Elderly Nutritional Index for Geriatric Malnutrition Assessment (ENIGMA) includes patient's capacity to shop, cook or feed himself, difficulty eating due to oral problem, fruits or vegetables consumption, use of five or more drugs a day and, related to blood indicators, were included low albumin, hemoglobin, total cholesterol, and LC. This tool has been validated for its use in the geriatric primary care setting [28]. However, even if correlation with MNA short form has been proved, low concordance between these tools suggest that they calculate malnutrition risk in a different way [29]. However, it's worth noting that NLR has not been previously incorporated as a biomarker of malnutrition in any established tool [6].

Another important aspect of this paper is the consistent direction of association preserved in linear regression models across various MNA approaches and the high degree of correlation between the tools. On the other hand, it shows that MNA-NLR can be useful as it demonstrated a strong correlation with the traditional MNA.

Regarding physical tests, all models showed largest association with them. It is known that increased inflammation and malnutrition have been associated with physical frailty and mobility [30]. As well as for cognitive performance [31], here the MMSE was significantly associated to all forms of screening malnutrition.

The present study has some limitations. First, as a secondary analysis, data was not recollected for the actual work purpose. Second, the cross-sectional design employed cannot stablish causality nor directionality. Third, it is important to notice that our data dates from 2009. However, our results still account for an underrepresented population where age-related studies are necessary due to unique patterns of ageing [32]. It is noteworthy to mention that the future of research involving this alternative should involve its comparison with a reference standard, a marker deemed as the most reliable indicator for malnutrition.

As known, albumin levels can offer insights into nutritional status. In our results, albumin showed higher degree of association and significance with the NLR approach. Despite albumin can also be influenced by factors beyond nutrition, such as inflammation or liver disease, its extended half-life makes it suitable as an indicator of longer-term nutritional status, aligning with our objectives and the target population in our community-based study [6].

This study has several strengths, including data having been collected from a representative sample from a country in Latin America [12]. The assessments have a well-organized structure and have undergone validation in various populations as part of other SABE studies [33]. The final sample is robust, consisting of a significant number of older adults living in the community, thereby bolstering the statistical power and reliability of the findings. We underscore the potential cost-effectiveness of NLR as a measure of nutritional status. While NLR is primarily recognized as an inflammation indicator, its close association with nutrition, especially in the context of older adults, chronic diseases, and malnutrition, is noteworthy. Monitoring NLR alongside other nutritional markers can deepen healthcare professionals' understanding of the complex interplay between nutrition, inflammation, and overall health.

Conclusion

Our study explored the substitution of BMI with NLR or LC in the MNA as a means of screening for malnutrition. The newly proposed models demonstrated strong correlation and concordance with the classic MNA, emphasizing similar markers of malnutrition risk. This suggests that hematological parameters may offer distinct insights into malnutrition compared to traditional anthropometric measures.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s00394-024-03392-0.

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Declarations

Ethical approval This study received ethical approval from the ethics and scientific committee of the Ageing Institute at Hospital Universitario San Ignacio and the Pontificia Universidad Javeriana ethics committee. SABE Ecuador was authorized by the Ecuadoran ministry of health authorities. All research procedures were conducted in accordance with the ethical standards outlined in the 1964 Declaration of Helsinki and its subsequent amendments. Measures were taken to protect the identity of the study subjects.

Conflict of interest The authors declare that they have no conflict of interest.

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