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Development and Validation of ViSarco: A Pragmatic Screening Tool for Sarcopenia in Primary Care

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Abstract

This study aimed to address the lack of accurate and straightforward sarcopenia screening tools in Vietnamese primary care by developing and validating ViSarco, a pragmatic anthropometry-based instrument for older adults. Using a sequential mixed-methods design, we reviewed the literature and worked with frontline providers to identify feasible screening items. In the development cohort (n = 416), criterion validity was established against DEXA, handgrip strength, and gait speed, and logistic regression identified body mass index (2 points), arm circumference (1 point), and calf circumference (1 point) as the strongest predictors. External validation in a large, stratified cohort (n = 806) using multifrequency BIA confirmed consistent performance across age, sex, and urban–rural strata. A cutoff score of ≥2 yielded 77.2% sensitivity and 76.6% specificity (AUC = 0.77) in the development phase and an AUC of 0.83 with 78.0% diagnostic accuracy in validation, outperforming six international comparators. ViSarco's novelty lies in its co-design, methodological rigor, and operational simplicity; relying solely on BMI, AC, and CC, it can be completed in minutes with negligible training and no equipment, making it well-suited for resource-limited primary care and offering a scalable model for sarcopenia screening in low- and middle-income countries.

Keywords: Sarcopenia; Screening Tool; Primary Health Care; Older Adults; Detection.

1. Introduction

Sarcopenia (ICD-10-CM M62.84) is a progressive geriatric syndrome characterized by the loss of skeletal muscle mass and function, and it has emerged as both a distinct pathological entity and a pressing global public health concern [1, 2]. Beginning in midlife, individuals may lose up to one-third of their muscle mass between the ages of 50 and 80, accompanied by increased weakness, fatigue, and functional decline that compromise mobility and increase fall risk. Consequently, older adults with sarcopenia experience disproportionately higher rates of falls, disability, hospitalization,

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and mortality, undermining individual well-being and straining healthcare systems, thereby jeopardizing the WHO's "Decade of Healthy Ageing" objectives [3-7].

Economically, sarcopenia imposes substantial burdens: in the United States, direct costs reached an estimated $18.5 billion in 2000 (approximately 1.5 % of total healthcare expenditures), with hospitalization costs up to 34 % higher among affected older adults [8]; in the United Kingdom, annual health and social care expenditures for people aged 71-80 with sarcopenia are projected at £2.5 billion [9]. Moreover, economic evaluations indicate that preventive interventions (structured exercise, protein, and vitamin D supplementation) can be cost-effective, yielding meaningful QALY gains within accepted willingness-to-pay thresholds [10]. In Vietnam, formal cost-of-illness studies for sarcopenia are not yet available; however, national data show that average healthcare expenditure per older person is markedly higher than for younger age groups (approximately 7–8 times higher), signaling a large individual- and system-level burden [11]. These observations support prioritizing low-cost, community-based screening and early preventive measures as a strategically cost-effective approach to reduce future disability-related expenditure and preserve function [7, 12].

Vietnam is undergoing one of the fastest demographic transitions in Southeast Asia, with nearly one-quarter of its population expected to be over 60 years old by 2050 [13]. Sarcopenia prevalence is high, affecting 32–47% of community-dwelling older adults and up to 69% of those in institutional care [14-16]. Although the EWGSOP2 and AWGS 2019 guidelines emphasize the importance of early detection, no standardized screening protocol exists in primary healthcare settings, and gold-standard diagnostic methods (dual-energy X-ray absorptiometry (DEXA) and bioelectrical impedance analysis (BIA)) remain costly and equipment-intensive, limiting their use in low- and middle-income countries (LMICs) [17-19]. Simplified tools, including SARC-F and limb-circumference-based measures, show limited sensitivity and may be miscalibrated when applied outside their development populations, reducing accuracy in LMIC contexts [20-22]. Recent systematic reviews and meta-analyses have highlighted that these instruments often demonstrate sensitivities as low as 30–40%, resulting in more than half of potential cases being missed, particularly in Asian and LMIC populations [23]. Furthermore, validation studies in China and Korea have shown that applying Western-derived cutoffs markedly reduces diagnostic accuracy, underscoring the need for culturally adapted, context-specific screening tools [24-26].

Despite the high prevalence of sarcopenia among older adults and the foundational role of primary healthcare (PHC) in universal health coverage, Vietnam currently lacks official screening guidelines or a context-appropriate, validated tool at this level of care [20-22, 27, 28].This gap severely limits early identification and timely intervention, hindering efforts to prevent functional decline and its long-term complications. With the growing clinical and economic burden of sarcopenia, there is an urgent need to develop a pragmatic screening instrument tailored to local conditions. Shifting from a late-stage, hospital-based diagnostic model to proactive, point-of-care detection would enable early interventions, targeted exercise, nutritional support, and lifestyle modification, which have been shown to slow muscle loss, reduce falls and hospitalizations, and preserve function [19, 22]. For policymakers, implementing cost-effective strategies such as routine screening, dietetic counseling, and community-based physical activity programs represents a feasible and sustainable alternative to technology-dependent diagnostics.

To address this gap, we developed and validated ViSarco, a pragmatic, context-sensitive community-based screening tool co-designed with frontline healthcare providers in Vietnam. Combining methodological rigour with local feasibility, ViSarco is adaptable to resource-limited primary-care settings. Using a sequential exploratory mixed-methods design, the study comprised two phases: (1) qualitative needs assessment and tool development, and (2) quantitative psychometric validation. The remainder of this article is structured as follows: Section 2 (Methods) describes the study design, participant recruitment, tool development procedures and statistical analyses. Section 3 (Results) reports item derivation and selection, exploratory factor analysis, reliability metrics and the diagnostic performance of the finalised instrument. Section 4 (Discussion) places the findings in the context of prior studies and outlines strengths, limitations, and implications for practice and policy. Finally, Section 5 (Conclusion) summarises the study's key contributions and the potential role of ViSarco in supporting healthy-ageing strategies in Vietnam and comparable settings.

2. Methods

This sequential exploratory mixed-methods study followed six key steps (Figure 1), including a PRISMA-compliant systematic review, COREQ-guided qualitative inquiry, and overarching methodological rigor ensured by the 2018 Mixed Methods Appraisal Tool. The protocol was approved by the Human Research Ethics Committee of Walailak University (WUEC 24 263 01; 24 July 2024), adhered to the Declaration of Helsinki, and written informed consent was obtained from all participants.

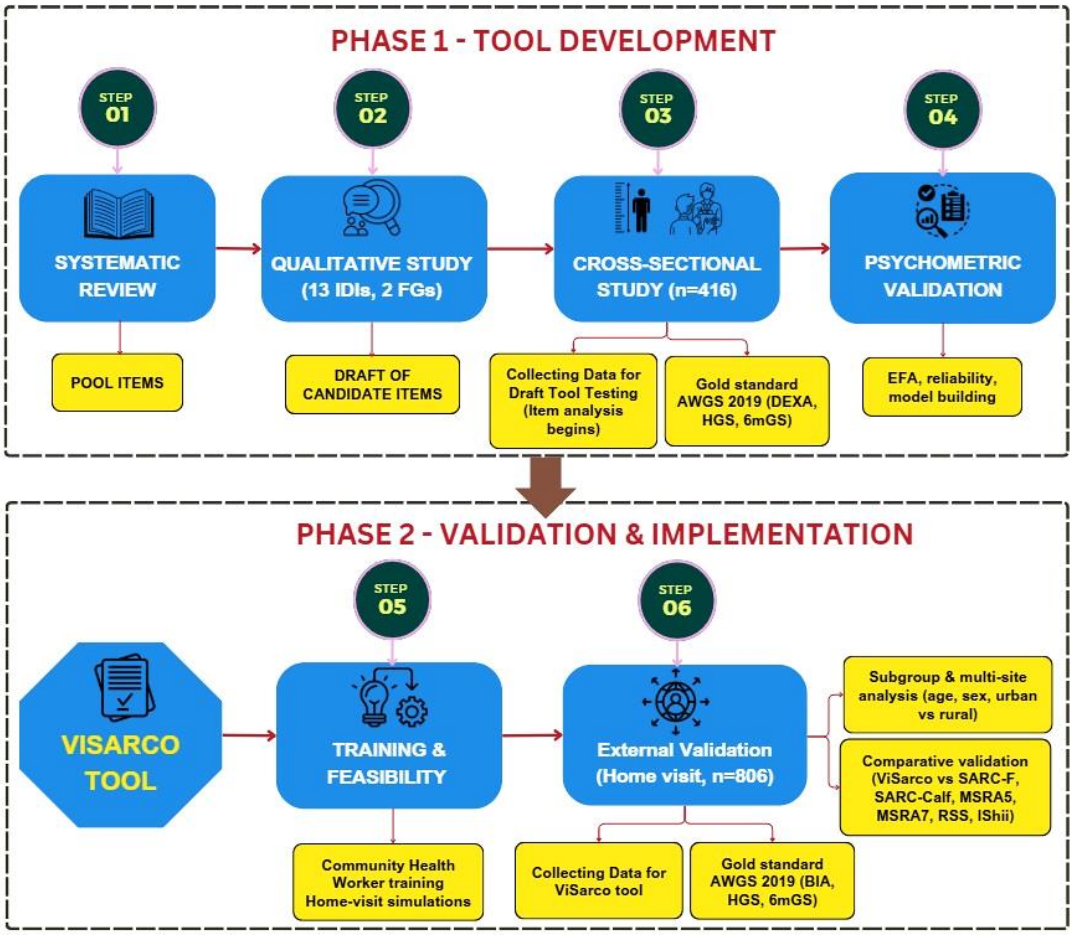

Figure 1. Overview of ViSarco development and validation process

Phase 1: Instrument Development

2.1. Targeted Literature Review

This review was registered with PROSPERO (CRD42024512949) and conducted in accordance with the PRISMA 2020 guidelines. A systematic search was performed across PubMed, Scopus, and Web of Science (2010–March 2024) via keywords related to "sarcopenia," "screening tool," "diagnosis," "older adults," and "validity."

The inclusion criteria were as follows: (1) studies involving community-dwelling adults aged ⩾60 years; (2) evaluation of sarcopenia screening tools with diagnostic accuracy metrics (sensitivity (Se), specificity (Sp), area under the receiver operating characteristic curve (AUC), positive likelihood ratio (PLR), and negative likelihood ratio (NLR)); (3) reference standards based on the EWGSOP, EWGSOP2, AWGS, FNIH, or IWGS; and (4) English-language publications.

The exclusion criteria were as follows: (1) nonpeer-reviewed sources (e.g., letters, commentaries, editorials, gray literature); (2) studies with insufficient or unverifiable data; (3) duplicates or lack of full-text availability; and (4) studies conducted in institutional or clinical settings, which were excluded to maintain focus on early detection in independent older adults.

Two independent reviewers screened all titles, abstracts, and full texts, with a third reviewer resolving any discrepancies. Study quality was assessed via the QUADAS-2 and COSMIN checklists, with interrater reliability evaluated via Cohen's kappa.

Findings from the review revealed that questionnaire-only tools demonstrated the lowest diagnostic performance (pooled AUC: 0.68 (0.63–0.72); sensitivity: 0.46 (0.33–0.59)). Tools combining questionnaires with anthropometric measures performed better (pooled AUC: 0.76 (0.73–0.80)), whereas multicomponent tools (Ishii) achieved the highest diagnostic accuracy (pooled AUC: 0.89 (0.85–0.92)).

These findings highlight current gaps and limitations in existing sarcopenia screening tools and directly inform the development of the ViSarco tool [23].

2.2. Qualitative Needs Assessment

To ensure the contextual relevance and feasibility of ViSarco in Vietnam's primary healthcare system, we conducted a qualitative needs assessment grounded in constructivist methodology. Thirty-seven primary care professionals in Can Tho were purposively sampled, including 13 individual in-depth interviews (IDIs) and 24 participants in two focus group discussions (FGDs). The participants included physicians (n=15), nurses (n=12), and physical therapists (n=10) across urban and semirural settings.

Data were collected from July to December 2024, transcribed verbatim, and analyzed via hybrid thematic analysis [29], which combines inductive and deductive coding. Two analysts independently coded the data, with discrepancies resolved through consensus and supervisory guidance. Rigor was ensured through member checking (n=10), triangulation, audit trials, and reflexivity. Intercoder reliability was supported by double coding and discussion. Data saturation was reached by the 37th participant.

This qualitative phase has been reported in detail in a separate manuscript currently under review. This process ensures that ViSarco is scientifically grounded, locally acceptable, and practical for early sarcopenia screening in community-based settings.

2.3. Cross-Sectional Survey

We recruited an independent sample of 416 community-dwelling adults (≥ 60 years) via multistage stratified random sampling in two Can Tho districts. The participants underwent whole-body DEXA (GE Lunar Prodigy), handgrip strength (HGS) testing (Jamar dynamometer), and a 6 m gait speed assessment (6 mGS) per the AWGS 2019 criteria. Anthropometrics, calf circumference (CC), body mass index (BMI), waist circumference (WC), and mid-upper arm circumference (AC) were measured via standardized protocols. The sample size exceeded Buderer's calculation (n = 379). Data quality was assured through daily instrument calibration, staff training, double data entry, and 10% random remeasurement.

The required sample size was estimated via Buderer's method [30], which is suitable for calculating sample size in diagnostic test accuracy studies on the basis of expected sensitivity and specificity, desired confidence level, and acceptable margin of error [31].

$$n = \frac{Z^2 p\,(1-p)}{W^2} \quad (1)$$

In this formula, n represents the required sample size; Z is the Z score at the 95% confidence level (1.96); p denotes the anticipated sensitivity or specificity; and W is the desired precision (10% or 0.1). According to a previous Vietnamese study [32], the expected values were a sensitivity of 66.7%, a specificity of 67.1%, and a prevalence of sarcopenia of 66.1%. The minimum required sample size was 379 (129 for sensitivity, 250 for specificity). In practice, we enrolled 416 participants, 215 of whom had sarcopenia and 201 of whom did not, surpassing the minimum sample size.

To determine context-specific anthropometric thresholds, the Youden index was applied to identify optimal cutoff points distinguishing individuals with and without sarcopenia. Univariate logistic regression was used to identify candidate items significantly associated with sarcopenia.

Measurements: Anthropometric measurements followed FANTA guidelines [33]. Weight and height were measured via a Seca 769 scale, and BMI was calculated. AC, CC, and WC were measured at standard anatomical landmarks via nonstretchable tape. Muscle mass was assessed by DEXA; low ASM was defined as < 7.0 kg/m² for men or < 5.4 kg/m² for women, per AWGS 2019. HGS was measured via a Jamar dynamometer, with the highest of three trials recorded. Low strength was defined as < 28 kg for men or < 18 kg for women. Gait speed was calculated from two 6-meter trials at the usual pace, with < 1.0 m/s classified as poor performance. Sarcopenia was diagnosed per AWGS 2019 as low muscle mass plus either low strength or poor physical performance.

2.4. Psychometric Evaluation and Score Development

Structural Exploration: Exploratory factor analysis (EFA) was used to identify the underlying dimensions of the draft item pool. Factors were retained on the basis of eigenvalues > 1.0, scree plot inspection, and interpretability.

Internal Consistency: Cronbach's alpha and corrected item–total correlations were computed for each factor. Items that failed to meet $\alpha \geq 0.70$ or that were poorly correlated were reviewed and removed.

Model Building: Bayesian model averaging and stepwise logistic regression were applied to the combined hospital and community datasets to select the most predictive items. Model fit was compared via the BIC, and clinical relevance guided final item inclusion.

Score Construction: Regression coefficients were rescaled relative to the smallest weight and rounded to the nearest integer. The optimal cutoff was determined by maximizing the Youden index in the derivation sample.

Phase 2: Validation and Implementation

2.5. Training and Feasibility

A standardized 2-day training workshop was delivered to community health workers, covering ViSarco's purpose, item administration, and scoring procedures. The program included theoretical instruction, hands-on demonstrations, and simulated home visits to enhance practical application. Field supervision was provided during early implementation to ensure protocol adherence.

2.6. External Validation and Comparative Assessment

An independent multisite sample of 806 community-dwelling older adults (urban and rural; diverse age and sex strata) was recruited. The finalized ViSarco tool was administered alongside established tools (SARC_F, SARC Calf, MSRA 5/7, RSS, and Ishii). Muscle mass was then measured by multi-frequency BIA (InBody 970), a method validated in an active-controlled clinical study demonstrating high concordance with whole-body DEXA (correlation coefficients >0.9 with Hologic QDR-4500 W and ≥0.83 with GE Lunar Prodigy). Grip strength and gait speed were assessed per the AWGS 2019 criteria. Diagnostic performance (sensitivity, specificity, AUC, likelihood ratios) was evaluated against the AWGS reference standard, with subgroup analyses by sex, age group, and site to confirm tool robustness across diverse populations [34, 35]. Diagnostic performance (sensitivity, specificity, AUC, likelihood ratios) was evaluated against the AWGS reference standard, and subgroup analyses by sex, age group, and site-assessed tool robustness across populations were performed.

3. Results

3.1. Item Pool Development Based on Literature Review and Healthcare Provider Insights

In accordance with the MMAT 2018 guidelines, Phase 1 commenced with an extensive literature review (Step 1), synthesizing existing sarcopenia screening tools for community-dwelling older adults. Tools were systematically categorized into the following main types: (1) questionnaire-based tools evaluating self-reported indicators of muscle strength, physical function, and lifestyle factors (e.g., SARC-F, MSRA-5/7, RSS); (2) anthropometric measures estimating muscle mass through indicators such as BMI, CC, AC, WC, and the finger-ring (Yubi-Wakka) test; and (3) physical performance assessments objectively measuring functional capacity, including grip strength, the chair stand test, gait speed, balance tests, the timed up-and-go (TUG), and the Short Physical Performance Battery (SPPB), (4) combinations of multiple methods (Ishii).

From this literature synthesis, a pool of candidate items was extracted, encompassing the following:

- 15 questionnaire items addressing subjective muscle strength, gait speed, muscle mass, physical performance, personal characteristics and lifestyle, and relevant medical history;
- 5 anthropometric measures (BMI, WC, CC, AC, and the finger-ring test);
- Six physical performance tests, including the SPPB, TUG, grip strength, chair stand, gait speed, and balance tests, were performed.

Qualitative inquiry and item refinement (step 2): We conducted a qualitative study with 37 primary healthcare providers from urban and rural communities across Vietnam (13 IDIs; 2 FGDs) to identify perceptions, challenges, and practical needs for sarcopenia screening in low-resource settings. Thematic analysis in NVivo highlighted two principal barriers. First, providers generally lack awareness and conceptual clarity, often regarding sarcopenia as an inevitable facet of Ageing rather than a diagnosable, treatable condition, limiting demand for any screening protocol. Second, systemic constraints, chiefly insufficient time, personnel, space, equipment, and rural accessibility, were consistently cited. As one focus group participant remarked, "Physical tests (TUG, SPPB) are quite complicated and time consuming, not suitable for elderly individuals. The medical station is very small and has no space to perform walk-in testing." (FG.02). Another noted, "Hand grip strength cannot be measured owing to lack of equipment." (FG.01). In addition, in-depth interview feedback added, "In our commune, elderly people do not have stairs, most houses are ground level, so some questions are meaningless." (IDI.04), "If we rely solely on questions, the results might not be accurate, since patients, especially older ones, can misreport or have poor memory." (IDI.08)

Guided by these insights, we refine our initial item pool to maximize local relevance and feasibility. The resulting draft comprises the following:

- Nineteen binary (yes/no) questionnaire items were used, with context inappropriate questions (e.g., "climbing stairs," "daily milk intake") removed and new risk factor items introduced per provider recommendations.
- Five anthropometric measures were selected for their simplicity, speed, and minimal equipment requirements.

- Two basic performance tests (chair stand and balance) and tests demanding specialized tools, space, or prolonged administration (grip strength, gait speed, SPPB, TUG) were excluded.

This codesign process ensured that the ViSarco candidate items were both scientifically grounded, on the basis of literature, and practically implementable in community-based primary care settings. The list of proposed items, initially derived from a literature review and subsequently refined through qualitative input, is presented in Appendix II as a context-appropriate and resource-sensitive item set.

3.2. Cross-Sectional Assessment and Early Validation of ViSarco

3.2.1. Item Selection and Anthropometric Thresholds

The Youden index was used to identify population-specific cutoffs for sarcopenia in older Vietnamese adults (Appendix I (Table A1)):

- BMI ≤ 22.6 kg/m² (men), 21.2 kg/m² (women)
- CC ≤ 31 cm (men), 30 cm (women)
- AC ≤ 25 cm (men), 24 cm (women)
- WC ≤ 86.5 cm (men), 74.5 cm (women)

Table 1. Results of univariate logistic regression for candidate item selection

No.	Candidate Items	OR	p_OR	AUC (95% CI)	p_AUC
I.1	Trouble moving in room	0.89	0.56	0.51 (0.47-0.56)	0.28
I.2	Walks faster than peers	1.13	0.52	0.52 (0.46-0.56)	0.26
I.3	Struggles to lift 5 kg	1.43	0.08	0.54 (0.49-0.59)	0.04
I.4	Struggles to stand up	1.11	0.58	0.51 (0.47-0.56)	0.29
I.5	Falls in the past year	1.15	0.60	0.51 (0.47-0.54)	0.30
I.6	Wring out towels or clothes	1.33	0.23	0.52 (0.48-0.56)	0.12
I.7	Feeling muscle strength vs. peers (weaker)	1.93	0.003	0.57 (0.53-0.61)	0.001
I.8	70 years and older	2.16	<0.001	0.59 (0.54-0.63)	<0.001
I.9	Walking ability	1.15	0.48	0.52 (0.47-0.57)	0.24
I.10	Protein intake frequency	1.07	0.81	0.5 (0.47-0.54)	0.41
I.11	Enough 3 meals	0.87	0.54	0.51 (0.47-0.55)	0.27
I.12	Hospitalizations last year	1.88	0.008	0.55 (0.51-0.59)	0.004
I.13	Weight loss last year	1.89	0.01	0.55 (0.51-0.59)	0.06
1.14	Gender male	2.17	<0.001	0.58 (0.54-0.63)	<0.001
1.15	>=3 chronic diseases	1.99	0.01	0.55 (0.51-0.58)	<0.001
I.16	Smoking	1.31	0.34	0.52 (0.48-0.55)	0.17
I.17	Drinks alcohol	0.78	0.57	0.50 (0.48-0.52)	0.44
I.18	Daily sleep hours.	1.21	0.38	0.52 (0.48-0.56)	0.19
I.19	Follow a diet	1.29	0.33	0.52 (0.48-0.55)	0.16
I.20	Ring finger	3.29	<0.001	0.64 (0.60-0.69)	<0.001
I.21	BMI_Vn threshold	13.1	<0.001	0.77 (0.73-0.81)	<0.001
I.22	Waist_Vn threshold	5.23	<0.001	0.69 (0.65-0.74)	<0.001
I.23	AC_Vn threshold	5.41	<0.001	0.70 (0.65-0.74)	<0.001
I.24	CC_Vn threshold	4.60	<0.001	0.68 (0.64-0.73)	<0.001
I.25	5-CST	1.35	0.13	0.54 (0.49-0.58)	0.07
I.26	Balance test_feet together stand	5511049	0.98	0.51 (0.50-0.52)	0.02
I.27	Balance test_semi-tandem stand	2.34	0.05	0.52 (0.50-0.55)	0.02
I.28	Balance test_tandem stand	1.65	0.03	0.54 (0.50-0.59)	0.02

Subsequent univariate logistic regression analysis of the 28 candidate items against the AWGS 2019 diagnostic standard identified 12 items significantly associated with sarcopenia ($p < 0.05$) for further consideration (Table 1). Notably, anthropometric measures (BMI, AC, CC, WC, finger-ring test) demonstrated strong associations (ORs 2.10–

13.1, $p < 0.001$) and higher discriminative power (AUCs 0.64–0.77) compared to questionnaire-based items, which showed weaker and often non-significant associations. This initial analysis highlighted the superior predictive value of objective measures within our study population.

3.2.2. Exploratory Factor Analysis (EFA)

EFA was performed to examine structural validity. Data suitability was confirmed (Kaiser–Meyer–Olkin = 0.73; Bartlett's test: $\chi^2 = 744.92$, $p < 0.001$). Parallel analysis and the scree plot supported a three-factor solution using minimum-residual extraction and varimax rotation (Appendix I (Figure A1)).

After inspecting the item loadings (Table 2), four items (Nos. 5, 6, 9, 12) with high uniqueness (> 0.90) and weak loadings (< 0.30) were removed, yielding an 8-item model that explained 30 percent of the total variance (Factor 1: 15 percent; Factor 2: 8 percent; Factor 3: 7 percent).

- Factor 1 (Overall Lean Mass): Defined by anthropometric thresholds (BMI, Waist, AC) and male sex (loadings 0.45–0.90), this factor represents general nutritional status and whole-body muscle mass.
- Factor 2 (Appendicular Muscle Mass): Comprising calf circumference and the finger-ring test (loadings 0.43–0.70), this factor captures peripheral muscle quantity, a key component of sarcopenia.
- Factor 3 (Muscle Function decline) included self-reported strength relative to peers and recent weight loss (loadings 0.46–0.52), capturing functional impairment.

This three-factor structure confirms that ViSarco items map cleanly onto (1) overall lean mass, (2) appendicular mass, and (3) muscle function, supporting its construct validity in primary-care settings.

Table 2. Extracted factors and associated items with significant loadings (≥ 0.30)

No.	Items	Uniquenesses	Factor 1	Factor 2	Factor 3
1	BMI_Vn threshold	0.40	0.67	0.34	
2	Waist_Vn threshold	0.18	0.90		
3	CC_Vn threshold	0.48		0.70	
4	Feeling muscle strength vs. peers (weaker)	0.72			0.52
5	70 years and older	0.91			
6	Hospitalizations last year	0.92			
7	Weight loss last year	0.77			0.46
8	Gender male	0.79	0.45		
9	>=3 chronic diseases	0.94			
10	Ring finger	0.73		0.43	
11	AC_Vn threshold	0.66	0.47	0.31	
12	Balance test_tandem stand	0.92			
SS loading			1.77	1.00	0.84
Proportion Var			0.15	0.08	0.07
CumulativeVar			0.15	0.23	0.30
The chi square statistic is 48.56 on 33 degrees of freedom. The p value is 0.0395					

3.2.3. Internal Consistency and Reliability of the Extracted Factors

The internal consistency of the factors was evaluated using Cronbach's alpha and inter-item correlations (Table 3). Factor 1 demonstrated good internal consistency (Cronbach's $\alpha = 0.73$). Removing the "Gender (male)" item increased α to 0.77, so it was excluded because of low item–total correlation (0.40). Factors 2 and 3, despite lower α values (0.52 and 0.36), had acceptable mean interitem correlations (0.35 and 0.22), which is consistent with short scales and indicates sufficient internal consistency.

All the items across the three factors had corrected item–total correlations ≥0.30, supporting their contribution to the overall structure.

ICC analysis revealed good reliability for Factor 1 (0.71–0.73), moderate reliability for Factor 2 (0.51–0.52), and low reliability for Factor 3 (0.33–0.36), suggesting the need for refinement of Factor 3 before inclusion in the final candidate items.

Table 3. Internal consistency metrics of ViSarco factors and items

Measure/Item	Cronbach's Alpha 95% CI	Alpha if Item Deleted	Average_r	r.cor	ICC
Overall Factor 1 (4 items)	0.73 (0.68-0.77)		0.4		0.71-0.73
Gender male		0.77		0.4	
BMI_Vn		0.61		0.73	
Waist_Vn		0.56		0.81	
AC_Vn		0.70		0.55	
Overall Factor 2 (2 items)	0.52 (0.43-0.61)		0.35		0.51-0.52
CC_Vn		0.35		0.49	
Ring finger		0.35		0.49	
Overall Factor 3 (2 items)	0.36 (0.24-0.48)		0.22		0.33-0.36
Feeling muscle strength vs. peers		0.26		0.37	
Weight loss last year		0.19		0.37	

Average_r (mean interitem correlation), r.cor (corrected item-total correlation)

3.3. Selection of the Optimal Model from Candidate Items

As shown in Table 4, both BMA and stepwise regression consistently identified BMI, CC, and AC as the strongest predictors of sarcopenia. These variables had the highest posterior inclusion probabilities (BMI and CC: 100%, AC: 85.6%), were statistically significant ($p < 0.01$), and BMI showed the largest effect (standardized $\beta = 0.43$). Model 1, which incorporated all three predictors, provided the best fit (lowest BIC = −164.83; adjusted $R^2 = 0.351$), indicating good explanatory power. In contrast, other candidate items had low inclusion probabilities and poor reliability (low ICC values), supporting their exclusion. The convergence of BMA and stepwise results confirms that the final ViSarco model should retain only BMI, CC, and AC, while systematically eliminating less robust measures. Additional details on the top five BMA models are presented in Appendix I (Table A2).

Table 4. Stepwise selection process and cumulative R^2 by step

Step	Variable	R^2	Adj. R^2	Beta	Std. Beta	SE	t	p
0	Base Mode	0.000	0.000	0.17	-	0.03	5.23	<0.001
1	BMI_Vn (+)	0.302	0.301	0.43	0.43	0.05	9.27	<0.001
2	CC_Vn (+)	0.342	0.338	0.18	0.18	0.04	4.32	<0.001
3	AC_Vn (+)	0.356	0.351	0.13	0.13	0.05	3.02	0.003

3.4. Weight Assignment and Optimal Cutpoint Identification for the ViSarco Tool

The regression coefficients from the final logistic model were used to assign integer scores to each item, creating a simple scoring system (Table 5). Three items, BMI, AC and CC below the Vietnamese threshold, were retained as significant predictors of sarcopenia. The regression coefficients were used to assign item scores by normalizing against the smallest coefficient and rounding to the nearest integer. BMI contributed the highest weight (score = 2), followed by CC (score = 1) and AC (score = 1), forming the final scoring scheme of the ViSarco tool.

Table 5. Logistic regression coefficients and assigned scores for ViSarco items (backward selection model)

Items	OR	95% CI	Regression coefficient	Assigned score*	Score
BMI_Vn threshold	8.18	(4.87-14.04)	2.10	2.84	2
AC_Vn threshold	2.10	(1.26-3.47)	0.74	1.00	1
CC_Vn threshold	2.81	(1.73-4.58)	1.03	1.39	1

* Assigned scores were calculated by dividing each regression coefficient by the smallest coefficient in the model, followed by rounding the result to the nearest whole number.

The diagnostic accuracy of the ViSarco score was evaluated at different cutpoints to identify the optimal threshold for screening (Table 6). A cutpoint of ≥2 was selected as it achieved the best balance between sensitivity (77.2%) and specificity (76.6%), maximizing the Youden Index (0.538). This threshold also yielded a strong Area Under the Curve (AUC = 0.769), a PLR of 3.3, and a NLR of 0.30, indicating a good ability to both rule in and rule out sarcopenia. While a cutpoint of ≥3 offered higher specificity (89.6%), it resulted in an unacceptable drop in sensitivity (63.7%), meaning too many true cases would be missed, a critical drawback for a community screening tool. Thus, the cutpoint of ≥2 was chosen to prioritize case-finding in the primary care context.

Table 6. Diagnostic accuracy of ViSarco at varying cutoff scores

Var X	OR	AUC	Sen	Spec	Youden's	PLR	NLR
Total score	2.65	0.832	-	-	-	-	-
Cutpoint ≥ 1	10.00	0.696	0.916	0.478	0.394	1.754	0.175
Cutpoint ≥ 2	11.10	0.769	0.772	0.766	0.538	3.302	0.297
Cutpoint ≥ 3	15.05	0.766	0.637	0.896	0.533	6.099	0.405
Cutpoint ≥ 4	14.56	0.691	0.433	0.950	0.383	8.694	0.597

3.5. Assessing the External Validity of the ViSarco Tool by Subgroup and Site

The extrapolation validity of the sarcopenia screening tool was assessed in 806 community-dwelling older adults. The tool showed an AUC of 0.77 (95% CI: 0.74–0.80) and an overall diagnostic accuracy of 78%. At a cutoff point ≥2, sensitivity was 72% and specificity was 82%. The PLR was 3.93, and the NLR was 0.34 (Table 7).

Subgroup analyses were conducted to examine performance across different populations:

- **Age:** AUC ranged from 0.73 to 0.79 across age groups, with the highest sensitivity observed in participants aged 70–79 years.
- **Sex:** Sensitivity was higher in men, while specificity was higher in women.
- **Area of residence:** Urban residents exhibited higher specificity and overall accuracy, whereas rural residents showed higher sensitivity.

Table 7. External validation and subgroup performance of the ViSarco tool

Sample (n=806)	AUC	sen	spec	PLR	NLR	Accuracy
Total (cutpoint ≥ 2)	**0.77 (0.74-0.80)**	**0.72**	**0.82**	**3.93**	**0.34**	**0.78**
Age (years old)						
• 60 – 69 (n=543)	0.75 (0.71-0.79)	0.67	0.83	3.94	0.39	0.78
• 70 – 79 (n=229)	0.79 (0.74-0.84)	0.79	0.79	3.81	0.27	0.79
• ≥ 80 (n=34)	0.73 (0.58-0.89)	0.75	0.71	2.63	0.35	0.74
Gender						
• Male (n=261)	0.79 (0.74-0.84)	0.88	0.70	2.91	0.17	0.78
• Female (n=545)	0.75 (0.71-0.79)	0.63	0.87	4.72	0.43	0.78
Area						
• Rural (n=355)	0.75 (0.71-0.80)	0.76	0.75	3.05	0.32	0.75
• Urban (n=451)	0.77 (0.72-0.81)	0.68	0.86	4.76	0.38	0.80

3.6. Comparison of ViSarco with Existing Sarcopenia Screening Tools

A head-to-head comparative assessment was conducted to evaluate ViSarco against six internationally established screening tools: SARC-F, SARC-Calf, RSS, MSRA-5, MSRA-7, and the Ishii score (Table 8). ViSarco achieved the highest AUC for both the total score (0.83) and the recommended cutpoint (0.77). Sensitivity and specificity were 72% and 82%, respectively.

Questionnaire-only tools (SARC-F, RSS, MSRA-5, MSRA-7) showed AUCs ranging from 0.53 to 0.56, with sensitivity between 29% and 39%. The hybrid tool SARC-Calf had an AUC of 0.64 and sensitivity of 50%. The Ishii score exhibited a sensitivity of 86% and specificity of 49%.

Figure 2 presents the Receiver Operating Characteristic (ROC) curves for all screening tools, illustrating the comparative diagnostic performance of each instrument.

Table 8. Comparative performance of ViSarco and six current sarcopenia screening tools

Sample (n= 806)		AUC (total score)	AUC (cutpoint)	sen	spec	PLR	NLR	Accuracy
SARC-F (cutpoint ≥ 4)	All	0.55 (0.51-0.59)	0.53 (0.50-0.56)	0.29	0.77	1.29	0.91	0.59
	Male	0.57 (0.51-0.64)	0.54 (0.50-0.59)	0.20	0.88	1.72	0.91	0.58
	Female	0.55 (0.50-0.60)	0.54 (0.50-0.58)	0.35	0.72	1.27	0.90	0.59
SARC-Calf (cutpoint ≥ 11)	All	0.74 (0.70-0.77)	0.64 (0.61-0.68)	0.50	0.79	2.34	0.64	0.67
	Male	0.76 (0.70-0.81)	0.64 (0.59-0.69)	0.41	0.87	3.14	0.68	0.67
	Female	0.73 (0.69-0.77)	0.65 (0.61-0.69)	0.55	0.75	2.22	0.60	0.68
RSS (cutpoint **≤14)**	All	0.58 (0.54-0.62)	0.55 (0.52-0.58)	0.31	0.80	1.52	0.87	0.61
	Male	0.62 (0.55-0.69)	0.55 (0.50-0.60)	0.22	0.88	1.88	0.89	0.59
	Female	0.57 (0.52-0.62)	0.56 (0.52-0.60)	0.36	0.76	1.50	0.84	0.61
MSRA5 (cutpoint < 45)	All	0.56 (0.52-0.60)	0.54 (0.51-0.58)	0.39	0.70	1.29	0.88	0.58
	Male	0.59 (0.52-0.66)	0.56 (0.50-0.61)	0.33	0.78	1.51	0.86	0.58
	Female	0.55 (0.50-0.60)	0.54 (0.50-0.58)	0.42	0.67	1.25	0.87	0.58
MSRA7 (cutpoint < 30)	All	0.55 (0.51-0.59)	0.54 (0.50-0.57)	0.37	0.70	1.24	0.90	0.57
	Male	0.55 (0.48-0.61)	0.54 (0.48-0.60)	0.35	0.73	1.30	0.89	0.56
	Female	0.55 (0.50-0.60)	0.53 (0.49-0.58)	0.38	0.69	1.21	0.90	0.57
Ishii (male ≤ 105, female ≤ 120)	All	0.78 (0.74-0.81)	0.68 (0.65-0.71)	0.86	0.49	1.69	0.28	0.64
	Male	0.83 (0.78-0.88)	0.67 (0.62-0.71)	0.93	0.40	1.56	0.17	0.63
	Female	0.75 (0.71-0.80)	0.67 (0.64-0.71)	0.82	0.52	1.73	0.34	0.63
ViSarco (cutpoint ≥ 2)	All	0.83 (0.80-0.86)	0.77 (0.74-0.80)	0.72	0.82	3.93	0.34	0.78
	Male	0.84 (0.79-0.89)	0.79 (0.74-0.84)	0.88	0.70	2.91	0.17	0.78
	Female	0.82 (0.78-0.85)	0.75 (0.71-0.79)	0.63	0.87	4.72	0.43	0.78

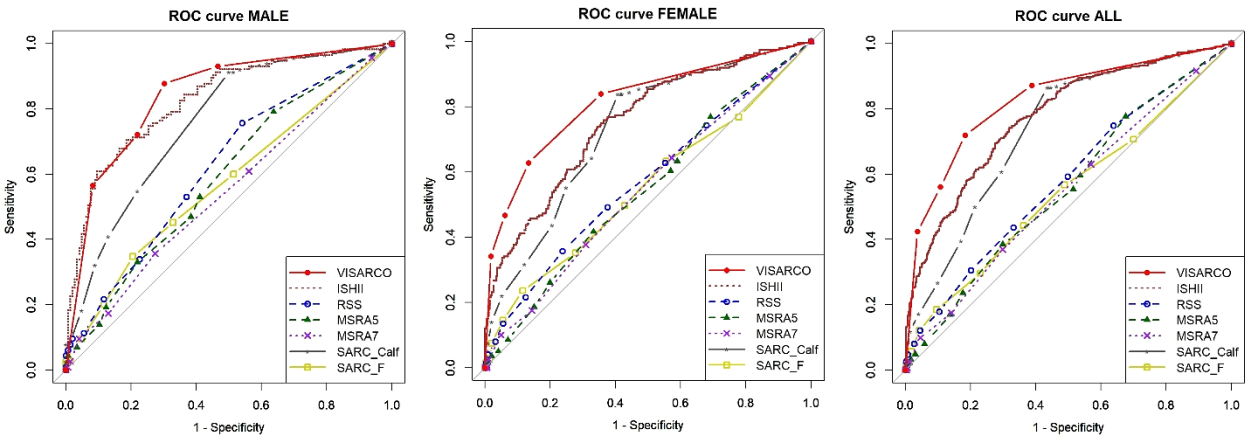

Figure 2. ROC curves comparing ViSarco with six established sarcopenia screening tools

4. Discussion

4.1. Theoretical Approach and Cultural Adaptation

The development of ViSarco was guided by a sequential exploratory mixed-methods design, reflecting principles of implementation science that emphasise contextual adaptation and active stakeholder engagement. Conceptually, the study is anchored in the biopsychosocial model of sarcopenia, which recognises that age-related muscle decline is influenced not only by biological ageing but also by nutrition, comorbidities, physical activity, and environmental factors [36]. This framework justified including anthropometric measures (BMI, AC, and CC) and frontline healthcare provider insights in the item selection, ensuring that the resulting tool captures clinically meaningful yet contextually feasible indicators [37]. The psychometric evaluation of ViSarco drew upon measurement theory, enabling the instrument to assess distinct but interrelated constructs of sarcopenia, overall lean mass, appendicular muscle mass, and functional decline, while demonstrating robust validity and reliability. By contrast, many existing instruments, such as SARC-F, MSRA, or the Ishii score, were primarily developed as pragmatic checklists without a strong theoretical foundation, limiting their cultural adaptability and often reducing sensitivity when applied outside the populations in which they were originally validated [38].

To address these limitations, ViSarco employed participatory action research (PAR) principles during co-design, engaging primary healthcare providers directly in tool development [39]. This approach enhanced the instrument's contextual relevance, operational feasibility, and acceptability, bridging the gap between theoretical models of sarcopenia and practical, community-based screening [40]. By integrating scientific rigour, local feasibility, and stakeholder input, ViSarco exemplifies how theory-driven research can be translated into a practical, culturally adapted screening tool suitable for resource-constrained primary healthcare settings.

In Vietnam, where Confucian values shape intergenerational relationships and perceptions of Ageing, functional decline is often regarded as a natural and inevitable process rather than a medical condition, leading to under-recognition of sarcopenia and reluctance to engage in screening, which may be perceived as unnecessary or stigmatizing. Traditional health beliefs that prioritize holistic remedies and passive acceptance over biomedical monitoring further reinforce this tendency. By integrating frontline provider perspectives, ViSarco reframes sarcopenia screening within a culturally resonant narrative centered on preserving functional independence and quality of life rather than medicalizing Ageing, thereby enhancing recognition, reducing stigma, and promoting uptake in resource-limited primary care, offering a transferable model for culturally adapted screening tools in similar contexts [41, 42].

4.2. Effectiveness and Feasibility of ViSarco in Primary Care Settings

This study developed and validated ViSarco, a simple and low-cost screening tool for sarcopenia based on three anthropometric indicators: BMI, upper arm circumference, and calf circumference. Designed for community use, ViSarco is particularly well-suited to the operational constraints of PHC systems in low-resource settings. Its balanced sensitivity and specificity support its role as a rapid and accurate method for early case detection in older adults [43, 44]. By eliminating the need for specialized equipment or complex procedures, ViSarco addresses key barriers to implementation in LMICs, enabling deployment across diverse PHC contexts, from urban clinics to rural outreach programs, and reducing socioeconomic and geographic disparities in access. Beyond structural constraints, cultural perceptions also hinder screening uptake: healthcare providers frequently regarded sarcopenia as an inevitable aspect of "normal Ageing,", limiting motivation for proactive case finding. By objectifying sarcopenia through simple, reproducible measurements, ViSarco shifts practice from subjective judgment to evidence-based screening, thereby improving acceptability in primary care. These strengths make it a promising candidate for integration into national healthy ageing strategies and community-based care models [43, 44].

ViSarco also demonstrates strong internal consistency and maintains diagnostic performance when externally validated across heterogeneous demographic subgroups, underscoring its generalizability. A key strength lies in its ability to minimize missed cases: high sensitivity and a low NLR in vulnerable populations (older age groups and rural residents) are critical, as undetected sarcopenia in these groups can rapidly accelerate functional decline. Conversely, high specificity and a strong PLR in younger and urban populations ensure that positive results are reliable, limiting false positives and avoiding unnecessary testing, anxiety, or referrals [45, 46]. This balance leads to an efficient primary care workflow, ensuring that resources (time, further assessment, referrals) are allocated appropriately, making the screening program sustainable and effective without burdening the health system or patients.

A distinctive feature of ViSarco is its contextual co-design, which represents a key determinant of successful implementation. Many diagnostic instruments originate from highly controlled or well-resourced research settings, often resulting in poor translation to real-world practice in LMICs [47]. By engaging PHC providers directly in the development process, this study identified and addressed barriers such as time limitations, lack of equipment, cultural sensitivity around specific questions, and recall difficulties among older adults. This participatory approach ensured that the tool was scientifically rigorous while remaining feasible and acceptable for providers and patients [47, 48], increasing its likelihood of adoption and sustainable integration into routine care.

Beyond its pragmatic advantages, ViSarco is also anchored in established theoretical frameworks of sarcopenia. International consensus definitions (EWGSOP 2, AWGS 2019) conceptualize sarcopenia as a multifactorial syndrome marked by progressive muscle mass, strength, and function decline [19, 49]. Anthropometric measures such as BMI, AC, and CC are biologically grounded proxies for muscle quantity and functional reserve, linking body composition with physiological vulnerability. By operationalizing these measures into a structured, reproducible score, ViSarco translates conceptual models into an actionable screening instrument [50]. Moreover, its design embodies principles of implementation science, which emphasize that effectiveness depends on validity and contextual adaptation. In this sense, ViSarco represents a theoretically informed, biologically plausible, and contextually tailored tool that bridges the gap between sarcopenia theory and its application in resource-constrained health systems [51, 52].

4.3. Comparison with Previous Tools

The anthropometric indices in ViSarco, BMI, upper arm circumference, and calf circumference, are both physiologically relevant and operationally feasible for primary care settings. BMI serves as a surrogate for overall nutritional status, whereas upper arm and calf circumferences provide direct measures of peripheral muscle mass, which

are hallmarks of sarcopenia [53, 54]. With an area under the ROC curve (AUC) of 0.83, ViSarco demonstrated a favorable diagnostic profile, with a sensitivity of 0.72 and a specificity of 0.82. Compared with six existing screening tools, ViSarco demonstrates superior performance, confirming its value as a simple, rapid, and reliable solution in resource-poor primary care settings. Questionnaire-based tools, including the SARC-F, RSS, MSRA-5, and MSRA-7, have shown limited clinical utility, often missing a significant proportion of sarcopenia cases. Their low sensitivity (30–40%) and likelihood ratios close to 1 suggest that relying solely on these tools could result in the absence of up to 60% of sarcopenia cases in community-based screening in Vietnam. Although simple to implement, these tools do not meet the performance threshold required for effective detection [23]. Complex prediction score–based tools, such as the Ishii score, demonstrated higher sensitivity (0.86) but markedly lower specificity (0.49), resulting in elevated false-positive rates and a greater likelihood of unnecessary follow-up testing. Moreover, the requirement for additional measurements, such as handgrip strength, limits its feasibility in PHC settings in Vietnam. In contrast, hybrid tools such as SARC-Calf, while having moderate specificity (0.79), have low sensitivity (0.50), resulting in missed diagnoses in approximately half of the real cases.

Our findings are consistent with prior Asian validation studies demonstrating superior diagnostic performance of simple anthropometric indices over questionnaire-only instruments for community sarcopenia screening. A study in older Chinese cohorts showed that CC alone has shown greater discriminative ability (AUC 0.819) than SARC-CalF, MSRA-5, and SARC-F, with substantially higher sensitivity and acceptable specificity [55]. An extensive community study in Thailand reported limited discrimination for SARC-F (AUC 0.508) and modest performance for SARC-CalF (AUC 0.729), whereas CC produced excellent accuracy (AUC 0.897 in men; 0.878 in women) [56]. In contrast, European studies have often emphasized grip strength or BIA as frontline screening measures [49], but such approaches are less feasible in primary care across LMICs due to equipment dependency and costs. ViSarco, integrating BMI with AC and CC, achieves a favorable balance between sensitivity and specificity while requiring minimal equipment and training. Identifying actual cases while minimizing inappropriate referrals is essential in resource-poor settings, where overloading already limited systems can compromise the quality of care. By achieving both accuracy and feasibility, ViSarco addresses a longstanding gap in sarcopenia detection and provides a scalable model for LMICs.

4.4. Strengths and Limitations of the Study

This study's sequential exploratory mixed-methods design, guided by the MMAT 2018 framework, combined a PROSPERO-registered, PRISMA-compliant systematic review with codesigned workshops involving frontline primary care providers to ensure methodological rigor and real-world relevance. Quantitative validation was conducted on large, stratified cohorts (n = 416 development; n = 806 external validation), that surpassed the recommended sample sizes and thereby increased statistical power. Criterion validity was established against gold standards (DEXA, HGS, 6 m GS). Moreover, psychometric properties were thoroughly evaluated via exploratory factor analysis, Cronbach's α, item–total correlations, Bayesian modeling, and stepwise logistic regression. External validation across age, sex, and urban/rural strata confirmed ViSarco's robustness, and head-to-head comparisons with six existing tools demonstrated its superior balance of sensitivity and specificity.

Despite its strengths, this study has two key limitations. First, different reference standards were applied across study phases: DEXA was used during tool development, whereas multifrequency BIA was employed for external validation due to its portability, lower cost, and feasibility in community settings. To minimize measurement bias, we utilized the InBody 970 device, which has been reported in multiple studies to exhibit an exceptionally high correlation with DXA for both appendicular and whole-body muscle mass [35, 57]. Nevertheless, potential device-specific bias cannot be entirely excluded and may have influenced the derived cutoff thresholds, particularly among women or individuals with atypical body composition [34]. Second, the study was conducted in a single urban area in southern Vietnam, which may restrict generalizability. Regional differences in culture, diet, health literacy, and health-care infrastructure could affect body composition norms and thus the performance of ViSarco in other settings.

4.5. Implications for Practice and Future Research

ViSarco offers a pragmatic response to the growing challenge of sarcopenia in primary care. By relying solely on BMI, AC, and CC, simple, rapid, and universally available measures, it provides an efficient alternative to equipment-dependent tools. The score can be generated in minutes, with negligible training requirements, and immediately informs tailored interventions centered on nutrition and exercise, currently the most effective means of preserving function without drug therapies [58, 59]. Crucially, its design anticipates the realities of frontline practice: integration adds minimal burden even in overstretched rural clinics. At the same time, its simplicity and objectivity enable equitable reach across socioeconomically disadvantaged and ethnolinguistically diverse populations.

Future research should establish ViSarco's prognostic validity through prospective cohort studies, testing its ability to predict long-term outcomes such as falls, functional decline, hospitalization, and mortality. Extending validation to institutionalized populations, where vulnerability to sarcopenia is particularly acute, will also be essential. Equally important are implementation studies examining provider uptake, patient engagement, and cost-effectiveness, ensuring

that the tool's promise translates into tangible health-system impact. At the policy level, accelerating the adoption of the Ministry of Health may require pilot integration into national community-based elderly care programs, accompanied by formal cost-effectiveness analyses and dissemination of findings through policy briefs and stakeholder workshops. The co-design approach underpinning ViSarco, grounded in local constraints yet built on universal anthropometry, offers a scalable model adaptable to other LMICs in Southeast Asia and beyond, facing similar demographic transitions and resource limitations.

5. Conclusion

ViSarco represents a pragmatic and scalable advancement for sarcopenia screening within PHC, developed through a rigorous sequential mixed-methods design and co-created with frontline practitioners. By integrating three universally accessible anthropometric indicators (BMI, AC, and CC) into a concise instrument requiring no specialized equipment and minimal training, it addresses the pressing need for efficient and equitable case identification. Across large stratified cohorts, ViSarco demonstrated robust diagnostic performance (AUC 0.77 in development; 0.83 in external validation), with an optimal cutoff of ≥2 achieving balanced sensitivity and specificity and an overall accuracy close to 78%. Comparative analyses against six established international instruments consistently confirmed its superiority: questionnaire-based tools such as SARC-F, MSRA, and RSS lacked sensitivity and overlooked a substantial proportion of cases; hybrid models such as SARC-Calf yielded only moderate accuracy; and even the complex Ishii score, though sensitive, generated excessive false positives. By contrast, ViSarco captured more true cases without overburdening referral pathways, reconciling clinical effectiveness with health-system sustainability. Beyond statistical performance, its contextual codesign and operational simplicity enhance acceptability, feasibility, and equity of access. These qualities are particularly salient in resource-constrained settings where equipment-dependent diagnostics remain impractical. By enabling earlier identification of at-risk older adults and triggering timely non-pharmacological interventions such as nutritional optimization and targeted exercise, ViSarco offers a realistic pathway to mitigate functional decline and promote healthy Ageing. Collectively, these characteristics establish ViSarco as a validated and pragmatic screening tool, offering a model that may be adapted to similar primary care contexts, especially in LMICs, where scalable and equitable approaches are urgently needed to promote healthy Ageing.

6. Declarations

6.1. Author Contributions

Conceptualization, H.T.N., C.N.L., C.S., and A.W.; methodology, H.T.N., C.S., A.W., W.S., and T.T.P.; software, H.T.N.; validation, H.T.N., T.N., and C.N.L.; formal analysis, H.T.N.; investigation, H.T.N., T.N., and C.N.L.; resources, H.T.N.; data curation, H.T.N.; writing—original draft preparation, H.T.N.; writing—review and editing, C.N.L., C.S., A.W., W.S., and T.T.P.; visualization, W.S. and T.T.P.; supervision, C.S., A.W., W.S., and T.T.P.; project administration, H.T.N.; funding acquisition, C.S. and A.W. All authors have read and agreed to the published version of the manuscript.

6.2. Data Availability Statement

The dataset generated and analyzed during the current study is available in the Zenodo repository at https://doi.org/10.5281/zenodo.15875782 under a Creative Commons Attribution 4.0 International license. The dataset contains only anonymized, nonidentifiable data.

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6.5. Institutional Review Board Statement

The study was conducted in accordance with the Declaration of Helsinki and approved by the Ethics Committee in Human Research of Walailak University (protocol code WUEC-24-263-01; approved on 24 July 2024).

6.6. Informed Consent Statement

Informed consent was obtained from all subjects involved in the study.

6.7. Declaration of Competing Interest

The authors declare that there are no conflicts of interest concerning the publication of this manuscript. Furthermore, all ethical considerations, including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancies have been completely observed by the authors.

7. References

[1] Anker, S. D., Morley, J. E., & von Haehling, S. (2016). Welcome to the ICD-10 code for sarcopenia. Journal of Cachexia, Sarcopenia and Muscle, 7(5), 512–514. doi:10.1002/jcsm.12147.

[2] Gao, Q., Hu, K., Yan, C., Zhao, B., Mei, F., Chen, F., Zhao, L., Shang, Y., Ma, Y., & Ma, B. (2021). Associated factors of sarcopenia in community-dwelling older adults: A systematic review and meta-analysis. Nutrients, 13(12), 4291. doi:10.3390/nu13124291.

[3] Beaudart, C., Zaaria, M., Pasleau, F., Reginster, J. Y., & Bruyère, O. (2017). Health outcomes of sarcopenia: A systematic review and meta-analysis. PLoS ONE, 12(1), 169548. doi:10.1371/journal.pone.0169548.

[4] Bruyère, O., Beaudart, C., Ethgen, O., Reginster, J. Y., & Locquet, M. (2019). The health economics burden of sarcopenia: a systematic review. Maturitas, 119, 61–69. doi:10.1016/j.maturitas.2018.11.003.

[5] Yuan, S., & Larsson, S. C. (2023). Epidemiology of sarcopenia: Prevalence, risk factors, and consequences. Metabolism: Clinical and Experimental, 144. doi:10.1016/j.metabol.2023.155533.

[6] Liu, J., Zhu, Y., Tan, J. K., Ismail, A. H., Ibrahim, R., & Hassan, N. H. (2023). Factors Associated with Sarcopenia among Elderly Individuals Residing in Community and Nursing Home Settings: A Systematic Review with a Meta-Analysis. Nutrients, 15(20), 4335. doi:10.3390/nu15204335.

[7] Darvishi, A., Hemami, M. R., Shafiee, G., Daroudi, R., Mohseni, M., Shekarabi, F. H., & Heshmat, R. (2021). Sarcopenia screening strategies in older people: a cost effectiveness analysis in Iran. BMC Public Health, 21(1), 926. doi:10.1186/s12889-021-10511-7.

[8] Sousa, A. S., Guerra, R. S., Fonseca, I., Pichel, F., Ferreira, S., & Amaral, T. F. (2016). Financial impact of sarcopenia on hospitalization costs. European Journal of Clinical Nutrition, 70(9), 1046–1051. doi:10.1038/ejcn.2016.73.

[9] Pinedo-Villanueva, R., Westbury, L. D., Syddall, H. E., Sanchez-Santos, M. T., Dennison, E. M., Robinson, S. M., & Cooper, C. (2019). Health Care Costs Associated with Muscle Weakness: A UK Population-Based Estimate. Calcified Tissue International, 104(2), 137–144. doi:10.1007/s00223-018-0478-1.

[10] Darvishi, A., Shafiee, G., Balajam, N. Z., Hemami, M. R., Ostovar, N., & Heshmat, R. (2023). Cost-effectiveness analysis of sarcopenia management interventions in Iran. BMC Public Health, 23(1), 819. doi:10.1186/s12889-023-15693-w.

[11] Nguyen, T. A., & Giang, L. T. (2021). Factors Influencing the Vietnamese Older Persons in Choosing Healthcare Facilities. Health Services Insights, 14, 11786329211017426. doi:10.1177/11786329211017426.

[12] Beaudart, C., Alcazar, J., Aprahamian, I., Batsis, J. A., Yamada, Y., Prado, C. M., Reginster, J. Y., Sanchez-Rodriguez, D., Lim, W. S., Sim, M., von Haehling, S., Woo, J., & Duque, G. (2025). Health outcomes of sarcopenia: a consensus report by the outcome working group of the Global Leadership Initiative in Sarcopenia (GLIS). Aging Clinical and Experimental Research, 37(1), 100. doi:10.1007/s40520-025-02995-9.

[13] Maheshwari, A., & Maheshwari, G. (2024). Aging Population in Vietnam: Challenges, Implications, and Policy Recommendations. International Journal of Aging, 2, e1. doi:10.34172/ija.2024.e1.

[14] Nguyen, T. Q. C., Nguyen, N. T. L., & Pham, P. T. T. C. (2023). Dietary Rations and the Status of Muscle Degradation in Elderly People at an Elderly Care Center in Hanoi In. Journal of Nutrition and Food, 19(4), 92–101. doi:10.56283/1859-0381/558. (In Vietnamese).

[15] Pham, L. A. T., Nguyen, B. T., Huynh, D. T., Nguyen, B. M. L. T., Tran, P. A. N., Van Vo, T., Bui, H. H. T., & Thai, T. T. (2024). Community-based prevalence and associated factors of sarcopenia in the Vietnamese elderly. Scientific Reports, 14(1), 17. doi:10.1038/s41598-023-50979-4.

[16] Tran, G. H., Ngo, L. P., Do, A. T., Le, T. K. O., Le, T. K. D., & Nguyen, T. H. (2025). Sarcopenia Situation and Some Related Factors in the Elderly in Phong Dien District, Can Tho City in 2024. Can Tho Journal of Medicine and Pharmacy, 83, 184–190. doi:10.58490/ctump.2025i83.3457. (In Vietnamese).

[17] Cruz-Jentoft, A. J., Baeyens, J. P., Bauer, J. M., Boirie, Y., Cederholm, T., Landi, F., Martin, F. C., Michel, J. P., Rolland, Y., Schneider, S. M., Topinková, E., Vandewoude, M., & Zamboni, M. (2010). Sarcopenia: European consensus on definition and diagnosis. Age and Ageing, 39(4), 412–423. doi:10.1093/ageing/afq034.

[18] Fielding, R. A., Vellas, B., Evans, W. J., Bhasin, S., Morley, J. E., Newman, A. B., Abellan van Kan, G., Andrieu, S., Bauer, J., Breuille, D., Cederholm, T., Chandler, J., De Meynard, C., Donini, L., Harris, T., Kannt, A., Keime Guibert, F., Onder, G., Papanicolaou, D., … Zamboni, M. (2011). Sarcopenia: An Undiagnosed Condition in Older Adults. Current Consensus Definition: Prevalence, Etiology, and Consequences. International Working Group on Sarcopenia. Journal of the American Medical Directors Association, 12(4), 249–256. doi:10.1016/j.jamda.2011.01.003.

[19] Chen, L. K., Woo, J., Assantachai, P., Auyeung, T. W., Chou, M. Y., Iijima, K., Jang, H. C., Kang, L., Kim, M., Kim, S., Kojima, T., Kuzuya, M., Lee, J. S. W., Lee, S. Y., Lee, W. J., Lee, Y., Liang, C. K., Lim, J. Y., Lim, W. S., … 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), 300-307.e2. doi:10.1016/j.jamda.2019.12.012.

[20] Dung, V., Thi Mai Lan, N., Thu Trang, V., Xuan Cu, T., Minh Thien, L., Sy Thu, N., Dinh Man, P., Minh Long, D., Trong Ngo, P., & Minh Nguyet, L. (2020). Quality of life of older adults in nursing homes in Vietnam. Health Psychology Open, 7(2), 2055102920954710. doi:10.1177/2055102920954710.

[21] Long, G. T. (2011). The aging Population in Viet Nam Current status, Prognosis, and Possible Policy Responses. United Nations Population Fund (UNFPA) in Viet Nam, Hanoi, Vietnam.

[22] Adulkasem, N., Vanitcharoenkul, E., Chotiyarnwong, P., Asavamongkolkul, A., & Unnanuntana, A. (2025). Evaluation of the Diagnosis Accuracy of the AWGS 2019 Criteria for "Possible Sarcopenia" in Thai Community-Dwelling Older Adults. Clinical Interventions in Aging, 20(null), 425–433. doi:10.2147/CIA.S513657.

[23] Nguyen, H. T., Suwanbamrung, C., Wattanapisit, A., Satheannoppakao, W., Nguyen, T., Truong, N. T., Ha, G. H., Huynh, D. T. N., & Le, C. N. (2025). Cultural Contexts Meet Clinical Precision: A Systematic Review and Meta-Analysis of Sarcopenia Screening Tools in Global Aging Communities. Journal of Posthumanism, 5(5), 1735–1769. doi:10.63332/joph.v5i5.1560.

[24] Yang, M., Hu, X., Xie, L., Zhang, L., Zhou, J., Lin, J., Wang, Y., Li, Y., Han, Z., Zhang, D., Zuo, Y., Li, Y., & Wu, L. (2018). Screening Sarcopenia in Community-Dwelling Older Adults: SARC-F vs SARC-F Combined With Calf Circumference (SARC-CalF). Journal of the American Medical Directors Association, 19(3), 277.e1-277.e8. doi:10.1016/j.jamda.2017.12.016.

[25] Kim, S., Kim, M., & Won, C. W. (2018). Validation of the Korean Version of the SARC-F Questionnaire to Assess Sarcopenia: Korean Frailty and Aging Cohort Study. Journal of the American Medical Directors Association, 19(1), 40-45.e1. doi:10.1016/j.jamda.2017.07.006.

[26] Lee, S. T., Lim, J. P., Tan, C. N., Yeo, A., Chew, J., & Lim, W. S. (2024). SARC-F and modified versions using arm and calf circumference: Diagnostic performance for sarcopenia screening and the impact of obesity. Geriatrics and Gerontology International, 24(S1), 182–188. doi:10.1111/ggi.14758.

[27] Health, T. M. O. (2020). Decision 1588/QD-BYT 2020 Professional Document Guidelines for Health Management of the Elderly. Health, T. M. O., Ministry of Health, Hanoi, Vietnam.

[28] Health, T. M. O. (2019). Decision 5904/QD-BYT 2019 document on Guidelines for diagnosing non-communicable diseases at commune health stations. Health, T. M. O., Ministry of Health, Hanoi, Vietnam.

[29] Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. Qualitative Research in Psychology, 3(2), 77–101. doi:10.1191/1478088706qp063oa.

[30] Fenn Buderer, N. M. (1996). Statistical methodology: I. Incorporating the prevalence of disease into the sample size calculation for sensitivity and specificity. Academic Emergency Medicine, 3(9), 895–900. doi:10.1111/j.1553-2712.1996.tb03538.x.

[31] Negida, A., Fahim, N. K., & Negida, Y. (2019). Sample Size Calculation Guide - Part 4: How to Calculate the Sample Size for a Diagnostic Test Accuracy Study based on Sensitivity, Specificity, and the Area Under the ROC Curve. Advanced Journal of Emergency Medicine, 3(3), e33. doi:10.22114/ajem.v0i0.158.

[32] Nguyen, T. N., Nguyen, A. T., Khuong, L. Q., Nguyen, T. X., Nguyen, H. T. T., Nguyen, T. T. H., Hoang, M. Van, Pham, T., Nguyen, T. N., & Vu, H. T. T. (2020). Reliability and validity of SARC-F questionnaire to assess sarcopenia among vietnamese geriatric patients. Clinical Interventions in Aging, 15, 879–886. doi:10.2147/CIA.S254397.

[33] Cashin, K. & Oot, L.. (2018). Guide to Anthropometry: A Practical Tool for Program Planners, Managers, and Implementers. Food and Nutrition Technical Assistance III Project (FANTA)/ FHI 360, U.S. Agency for International Development (USAID), Washington, United States.

[34] Sun, G., French, C. R., Martin, G. R., Younghusband, B., Green, R. C., Xie, Y. G., Mathews, M., Barron, J. R., Fitzpatrick, D. G., Gulliver, W., & Zhang, H. (2005). Comparison of multifrequency bioelectrical impedance analysis with dual-energy X-ray absorptiometry for assessment of percentage body fat in a large, healthy population. American Journal of Clinical Nutrition, 81(1), 74–78. doi:10.1093/ajcn/81.1.74.

[35] Ha, Y. C., Kim, S., & Yoo, J. Il. (2024). Open, Active-Controlled Clinical Study to Evaluate the Correlation between Whole Body DEXA and BIA Muscle Measurements. Journal of Bone Metabolism, 31(3), 219–227. doi:10.11005/jbm.2024.31.3.219.

[36] Kara, M., Kaymak, B., Frontera, W. R., Ata, A. M., Ricci, V., Ekiz, T., Chang, K. V., Han, D. S., Michail, X., Quittan, M., Lim, J. Y., Bean, J. F., Franchignoni, F., & Özçakar, L. (2021). Diagnosing sarcopenia: Functional perspectives and a new algorithm from ISarcoPRM. Journal of Rehabilitation Medicine, 53(6), 209. doi:10.2340/16501977-2851.

[37] Potthoff, S., Finch, T., Bührmann, L., Etzelmüller, A., van Genugten, C. R., Girling, M., May, C. R., Perkins, N., Vis, C., & Rapley, T. (2023). Towards an Implementation-STakeholder Engagement Model (I-STEM) for improving health and social care services. Health Expectations, 26(5), 1997–2012. doi:10.1111/hex.13808.

[38] Voulgaridou, G., Tyrovolas, S., Detopoulou, P., Tsoumana, D., Drakaki, M., Apostolou, T., Chatziprodromidou, I. P., Papandreou, D., Giaginis, C., & Papadopoulou, S. K. (2024). Diagnostic Criteria and Measurement Techniques of Sarcopenia: A Critical Evaluation of the Up-to-Date Evidence. Nutrients, 16(3), 436. doi:10.3390/nu16030436.

[39] Son, B. K., Miura, T., Yabu, K. I., Sumikawa, Y., Kim, D., Lyu, W., Yang, Y., Tanaka, M., Tanaka, T., Yoshizawa, Y., & Iijima, K. (2023). The Co-Design/Co-Development and Evaluation of an Online Frailty Check Application for Older Adults: Participatory Action Research with Older Adults. International Journal of Environmental Research and Public Health, 20(12), 6101. doi:10.3390/ijerph20126101.

[40] Valenta, S., Ribaut, J., Leppla, L., Mielke, J., Teynor, A., Koehly, K., Gerull, S., Grossmann, F., Witzig-Brändli, V., & De Geest, S. (2022). Context-specific adaptation of an eHealth-facilitated, integrated care model and tailoring its implementation strategies—A mixed-methods study as a part of the SMILe implementation science project. Frontiers in Health Services, 2, 977564. doi:10.3389/frhs.2022.977564.

[41] Nguyen, T. N. M., Saunders, R., Dermody, G., & Whitehead, L. (2024). The influence of culture on the health beliefs and health behaviours of older Vietnam-born Australians living with chronic disease. Journal of Advanced Nursing, 80(9), 3781–3796. doi:10.1111/jan.16283.

[42] Thị Minh Thi, T. (2019). Institutional and cultural aspects of care for rural elderly people in Vietnam. Wieś i Rolnictwo, 3 (184), 11–30. doi:10.53098/wir032019/01. (In Polish).

[43] Seidell, J. C., Kahn, H. S., Williamson, D. F., Lissner, L., & Valdez, R. (2001). Report from a centers for disease control and prevention workshop on use of adult anthropometry for public health and primary health care. American Journal of Clinical Nutrition, 73(1), 123–126. doi:10.1093/ajcn/73.1.123.

[44] Ha, T. C., McNamara, M., Melo, L., Frost, E. K., & Moore, G. M. (2023). Filling the gap between evidence, policy and practice: are 45 and up Study researchers planning for impact? Public Health Research and Practice, 33(1), 45. doi:10.17061/phrp32122207.

[45] Trevethan, R. (2020). Response: Commentary: Sensitivity, Specificity, and Predictive Values: Foundations, Pliabilities, and Pitfalls in Research and Practice. Frontiers in Public Health, 7, 2019. doi:10.3389/fpubh.2019.00408.

[46] Ben-Haim, Y., & Dacso, C. C. (2024). Interpreting PPV and NPV of Diagnostic Tests with Uncertain Prevalence. Rambam Maimonides Medical Journal, 15(3), 10527. doi:10.5041/RMMJ.10527.

[47] Dekker-Van Doorn, C., Wauben, L., Van Wijngaarden, J., Lange, J., & Huijsman, R. (2020). Adaptive design: Adaptation and adoption of patient safety practices in daily routines, a multi-site study. BMC Health Services Research, 20(1), 426. doi:10.1186/s12913-020-05306-2.

[48] Carlfjord, S., Lindberg, M., Bendtsen, P., Nilsen, P., & Andersson, A. (2010). Key factors influencing adoption of an innovation in primary health care: A qualitative study based on implementation theory. BMC Family Practice, 11(1), 60. doi:10.1186/1471-2296-11-60.

[49] Cruz-Jentoft, A. J., Bahat, G., Bauer, J., Boirie, Y., Bruyère, O., Cederholm, T., Cooper, C., Landi, F., Rolland, Y., Sayer, A. A., Schneider, S. M., Sieber, C. C., Topinkova, E., Vandewoude, M., Visser, M., Zamboni, M., Bautmans, I., Baeyens, J. P., Cesari, M., … Schols, J. (2019). Sarcopenia: Revised European consensus on definition and diagnosis. Age and Ageing, 48(1), 16–31. doi:10.1093/ageing/afy169.

[50] Rolland, Y., Lauwers-Cances, V., Cournot, M., Nourhashémi, F., Reynish, W., Rivière, D., Vellas, B., & Grandjean, H. (2003). Sarcopenia, calf circumference, and physical function of elderly women: A cross-sectional study. Journal of the American Geriatrics Society, 51(8), 1120–1124. doi:10.1046/j.1532-5415.2003.51362.x.

[51] Streiner, D. L., Norman, G. R., & Cairney, J. (2014). Health Measurement Scales. Oxford University Press, Oxford, United Kingdom. doi:10.1093/med/9780199685219.001.0001.

[52] Peters, D. H., Adam, T., Alonge, O., Agyepong, I. A., & Tran, N. (2014). Republished research: Implementation research: What it is and how to do it. British Journal of Sports Medicine, 48(8), 731–736. doi:10.1136/bmj.f6753.

[53] Luo, S., Chen, X., Hou, L., Yue, J., Liu, X., Xia, X., Dong, B., & Cao, L. (2023). The accuracy of body mass index and calf circumference values when assessing sarcopenia in a multi-ethnic cohort of middle-aged and older adults: West China health and aging trend study results. Heliyon, 9(4), 15027. doi:10.1016/j.heliyon.2023.e15027.

[54] Wang, B., Nong, C., Zhang, J., Deng, L., Li, W., Zhang, X., & Liu, P. (2024). Prevalence and associated body composition factors of sarcopenia in community-dwelling older adults. European Journal of Medical Research, 29(1), 598. doi:10.1186/s40001-024-02185-9.

[55] Chen, C. Y., Tseng, W. C., Yang, Y. H., Chen, C. L., Lin, L. L., Chen, F. P., & Wong, A. M. K. (2020). Calf circumference as an optimal choice of four screening tools for sarcopenia among ethnic Chinese older adults in assisted living. Clinical Interventions in Aging, 15, 2415–2422. doi:10.2147/CIA.S287207.

[56] Vanitcharoenkul, E., Unnanuntana, A., Chotiyarnwong, P., Adulkasem, N., Asavamongkolkul, A., & Laohaprasitiporn, P. (2024). Evaluating SARC-F, SARC-CalF, and calf circumference as diagnostic tools for sarcopenia in Thai older adults: results from a nationwide study. BMC Geriatrics, 24(1), 1043. doi:10.1186/s12877-024-05637-3.

[57] Yi, Y., Baek, J. Y., Lee, E., Jung, H. W., & Jang, I. Y. (2022). A Comparative Study of High-Frequency Bioelectrical Impedance Analysis and Dual-Energy X-ray Absorptiometry for Estimating Body Composition. Life, 12(7), 994. doi:10.3390/life12070994.

[58] Xie, W. Q., Xiao, G. L., Hu, P. W., He, Y. Q., Lv, S., & Xiao, W. F. (2020). Possible sarcopenia: Early screening and intervention-narrative review. Annals of Palliative Medicine, 9(6), 4283–4293. doi:10.21037/apm-20-967.

[59] Won, C. W. (2023). Management of Sarcopenia in Primary Care Settings. Korean Journal of Family Medicine, 44(2), 71–75. doi:10.4082/kjfm.22.0224.

Appendix I

Table A1. Optimal cut-off values and diagnostic performance of anthropometric indicators by gender

Indicator	Gender	Optimal Cut-off	Sensitivity	Specificity	Youden Index (J)
BMI (kg/m^2)	Male	22.59	0.79	0.79	0.58
	Female	21.15	0.62	0.90	0.51
	Combined	22.59	0.79	0.72	0.51
CC (cm)	Male	30.75	0.57	0.92	0.49
	Female	30.30	0.63	0.71	0.35
	Combined	30.40	0.60	0.77	0.36
AC (cm)	Male	24.75	0.75	0.75	0.50
	Female	23.75	0.59	0.78	0.36
	Combined	24.05	0.69	0.70	0.39
WC (cm)	Male	86.50	0.86	0.50	0.36
	Female	74.25	0.47	0.84	0.31
	Combined	75.25	0.46	0.82	0.27

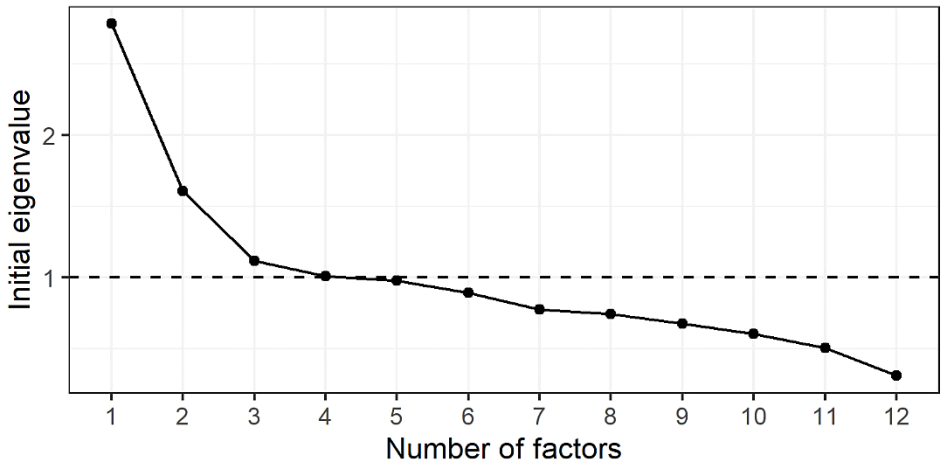

Figure A1. Scree plot of initial eigenvalues from exploratory factor analysis

Table A2. Top five models selected on the basis of posterior probability and BIC (BMA results)

Items	PIP (%)	Postmean β (SD)	Model 1	Model 2	Model 3	Model 4	Model 5
BMI_Vn	100	0.44(0.05)	0.43	0.49	0.42	0.42	0.41
Waist_Vn	4	0.001(0.01)	-	-	-	-	0.03
AC_Vn	85.6	0.12(0.06)	0.14	-	0.14	0.14	0.13
Ring finger	6.9	0.004(0.02)	-	-	.	0.05	-
CC_Vn	100	0.19(0.04)	0.18	0.21	0.18	0.17	0.19
Feeling muscle strength vs. peers	8.3	0.004(0.02)	-	-	0.06	-	-
Weight loss last year	0.0	0.00(0.00)	-	-	-	-	-
nVar			3	2	4	4	4
r2			0.36	0.34	0.36	0.36	0.36
BIC			-164.83	-161.76	-160.66	-160.31	-159.19
Post prob			0.67	0.14	0.08	0.07	0.04

Appendix II

Table A3. Refinement of Candidate Items Based on Primary Healthcare Provider Feedback

Characteristics	Items from literature review	Items after revised by qualitative study
Subjective muscle strength, gait speed, muscle mass, physical performance	1.Subjective gait speed_How much difficulty do you have walking across a room? (In the past 3 months, you have noticed that you walk, how fast do you usually walk?) • None • Some • A lot or unable	1. Do you have trouble moving in the house? • Yes • No
	2. How do you feel your muscle strength compares to others of your age and sex? • Very weak • Weak • Average • Strong • Very strong	2. Do you walk faster than your peers? • Yes • No Same question number 7
	3.Subjective muscular Strength_How much difficulty do you have in lifting and carrying 10 pounds? • None • Some • A lot, use aids, or unable	3. Do you have difficulty lifting a 5 kg object (like a 5 kg bag of rice or a 5 liter can of cooking oil)? • Yes • No
	4. Subjective muscular Strength_How much difficulty do you have climbing a flight of 10 stairs? • None • Some • A lot or unable	**DELETED (because of in rural areas most of the houses are ground floor)**
	5. How much difficulty do you have transferring from a chair or bed? • None • Some • A lot or unable without help	4. Do you struggle to stand up when transferring from a chair or bed? • Yes • No
	6. How many times have you fallen in the past year? • None • 1-3 falls • ≥4 falls	5. Have you fallen more than two times in the past year? • Yes • No
	7. How much can you squeeze a wet towel? • Can squeeze approximately 70% or tightly squeeze • Can squeeze approximately 50% • Can barely squeeze	6. Can you squeeze water out of a wet towel or clothes until they are more than halfway dry? • Yes • No
	8. How much muscle strength do you think you have compared with that of people of your age and sex? • About the same/ more • Somewhat less • Less	7.Do you feel your muscle strength is stronger than that of your peers? • Yes • No
Personal characteristics and living Habits	9. How old are you? • ≥ 70 years old • < 70 years old	8. Are you 70 years old or older? • Yes • No
	10. What is your activity level? (/Absence of exercise) • I'm able to walk more than 1000 meters • I'm able to walk 500 - 1000 meters • I'm able to walk less than 500 meters	9. Can you walk more than 500 meters? • Yes • No
	11. Do you consume any of the following? (rich protein food) • Every day • 3-4 times per week • Rarely or under 2 times per week	10. Do you consume protein-rich foods regularly (poultry, meat, fish, eggs, legumes, ragout, or ham)? • Yes • No
	12. Do you eat 3 meals per day regularly? • Yes • No, up to twice per week I skip a meal • No, I often skip meals (morning or evening)	11. Do you eat three meals per day regularly? • Yes • No
	13. Do you consume any of the following? (milk and dairy products) • Every day • 3-4 times per week • Rarely or under 2 times per week	**DELETED** (because in VN there is no habit of drinking milk in daily)

Medical history	14. Were you hospitalized in the last year? • No • Yes 1 hospitalization • Yes, and more than 1 hospitalization	12. Have you been hospitalized in the last year? • Yes • No
	15. Do you lose weight in the last year? • No or ≤2 kg • Lost 3-4 kg • Lost ≥ 5 kg	13. Have you lost more than 2 kg in the last year? • Yes • No
Risk factor		14. Gender is Male • Yes • No
		15. Please list all chronic illnesses you have. Do you have three or more chronic illnesses? • Yes • No
		16. Do you smoke? • Yes • No
		17. Do you drink alcohol? • Yes • No
		18. Do you sleep less than 8 hours daily? • Yes • No
		19. Do you follow a specific diet? • Yes • No
Anthropometric	BMI, WC, CC, 2MUAC Ring finger test? • Larger • Just fit • Tight	BMI, WC, CC, MUAC Please use the thumb and index finger of both hands to form a circle and wrap them around the thickest part of your calf (as shown in the illustration). Is the circle bigger than your calf? • Yes • No
Physical performance test	SPPB, Up and go test, Grip strength, Chair stand test, Gait speed, balance test	Chair stand test, balance test (Excluded SPPB, Up and Go, grip strength, and gait speed due to space constraints, equipment needs, and time consumption)