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Mid-upper arm circumference and Neck Circumference as optimal proxies for Body Mass Index in the Assessment of Malnutrition and Metabolic Risks among the Older Adults in the Rural region of Delhi-NCR, India

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Abstract

Introduction: BMI is traditionally used as a screening tool to assess malnutrition and evaluate metabolic risks among older adults. But it can misclassify individuals with a low muscle-to-fat ratio by masking progressive muscle loss and simultaneous visceral adiposity. Also, the compression of the vertebral column in older adults raises questions about the validity of height-dependent BMI calculations. Therefore, this study aims to evaluate the utility of MUAC and NC as practical somatometric proxies for BMI among community-dwelling older adults in rural Delhi-NCR, India. **Methods:** A total of 404 participants, aged 60 years or older, were included in this study. Anthropometric variables were assessed using standardized instruments following the International Society for the Advancement of Kinanthropometry (ISAK) protocols, i.e., height using an Anthropometer rod; weight using an Omron Karada Scan Body Composition Monitor HBF-375; and MUAC, NC, and CC using a Cescorf anthropometric tape**.** Statistical significance was defined as $\rho>0.60$ and $p<0.05$. Low CC was treated as an indicator of a low muscle-to-fat ratio, a measure of malnutrition, and NC as a biomarker of metabolic risk. **Results:** NC was significantly correlated with BMI in both males and females ($p<0.001$). Similarly, among individuals with low CC ($n=250$), a significantly strong correlation between CC and MUAC was observed ($p<0.001$) when stratified by sex. Further, 40.40% of the individuals with low CC were misclassified as normal weight, regardless of having a low muscle-to-fat ratio. **Conclusion:** BMI masks progressive loss in muscle mass and can misclassify older adults while screening for metabolic risks. Hence, it may be an inadequate tool for assessing malnutrition and metabolic risks in the geriatric population. Therefore, using tape measurements such as MUAC and NC in screening older adults for malnutrition and metabolic risks may yield better results.

Keywords: Somatometry, Calf circumference, Community-based, Sarcopenia, General Obesity

Resumen

Introducción: El Índice de Masa Corporal (IMC) se utiliza tradicionalmente como herramienta de cribado para evaluar la desnutrición y los riesgos metabólicos en adultos mayores. Sin embargo, puede clasificar erróneamente a personas con una baja relación músculo-grasa al enmascarar la pérdida progresiva de masa muscular y la adiposidad visceral simultánea. Asimismo, la compresión de la columna vertebral en los adultos mayores plantea dudas sobre la validez de los cálculos del IMC, que dependen de la estatura. Por ello, este estudio tiene como objetivo evaluar la utilidad del perímetro del brazo (MUAC) y del perímetro del cuello (NC) como indicadores somatométricos prácticos sustitutos del IMC en adultos mayores residentes en la comunidad de la zona rural de Delhi-NCR, India. **Métodos:** Se incluyó en el estudio a un total de 404 participantes de 60 años o más. Las variables antropométricas se evaluaron mediante instrumentos estandarizados siguiendo los protocolos de la Sociedad Internacional para el Avance de la Cineantropometría (ISAK): estatura con un antropómetro de varilla; peso con un monitor de composición corporal Omron Karada Scan HBF-375; y MUAC, NC y perímetro de la pantorrilla (CC) con una cinta antropométrica Cescorf. Se definió significación estadística para $\rho > 0,60$ y $p < 0,05$. Un valor bajo de CC se consideró indicador de una baja relación músculo-grasa (medida de desnutrición), y el NC

como biomarcador de riesgo metabólico. **Resultados:** El NC mostró una correlación significativa con el IMC tanto en hombres como en mujeres ($p < 0,001$). Del mismo modo, entre los individuos con CC baja ($n = 250$), se observó una correlación significativamente fuerte entre la CC y el MUAC ($p < 0,001$) al estratificar por sexo. Además, el 40,40 % de los individuos con CC baja fueron clasificados erróneamente como normopeso, a pesar de presentar una baja relación músculo-grasa. **Conclusión:** El IMC enmascara la pérdida progresiva de masa muscular y puede clasificar erróneamente a los adultos mayores durante el cribado de riesgos metabólicos. Por consiguiente, podría ser una herramienta inadecuada para evaluar la desnutrición y los riesgos metabólicos en la población geriátrica. Así, el uso de mediciones con cinta, como el MUAC y el NC, para el cribado de desnutrición y riesgos metabólicos en adultos mayores podría ofrecer mejores resultados.

Palabras clave: Somatometría, Perímetro de la pantorrilla, Basado en la comunidad, Sarcopenia, Obesidad general.

Introduction

The global population is aging at an unprecedented rate, posing serious public health challenges in densely populated nations like India. India's geriatric population (aged 60 and above) has reached approximately 138 million, accounting for 10.1% of the total population, with 71% residing in rural areas (United Nations Population Fund [UNFPA], 2023; Ministry of Statistics and Programme Implementation [MoSPI], 2016). Demographic projections indicate that the older adult population will increase to 230 million by 2036 and surpass 347 million by 2050, accounting for over 20.8% of the country's population (UNFPA, 2023). This demographic shift has further increased the prevalence of age-related health complications among older adults, often with overlapping etiologies, and has prompted public health frameworks to restructure standard screening protocols (Guo et al., 2022; Kshatriya et al., 2021).

Traditionally, field-based health programs have depended on Body Mass Index (BMI) to screen older adults for malnutrition and metabolic risks. However, this reliance on BMI poses various diagnostic challenges when applied to geriatric populations (Cruz-Jentoft et al., 2019), as aging is accompanied by various physiological changes, including alterations in body composition characterized by increased adiposity, reduced skeletal muscle mass, and redistribution of body fat (Kaur et al., 2025). Further, the progressive loss of muscle mass, known as sarcopenia, is often masked by a concurrent increase in visceral adiposity (Kaur et al., 2025). This creates the 'thin-fat' phenotype uniquely prevalent in South Asian populations, meaning that severe muscle wasting in the individual hides behind a normal or overweight BMI value (Kaur et al., 2025; Malik & Goel, 2024). Simultaneously, aging causes progressive spinal compression, vertebral flattening, and a systematic decrease in an individual's height over time (Holt et al., 2023). This physiological change mathematically inflates BMI calculations without reflecting actual gains/loss in muscle mass. Therefore, using BMI alone to assess older adults for public health interventions may lead to their widespread misclassification (Das et al., 2018).

Therefore, shifting from height- and weight-dependent BMI metrics to alternate anthropometric measures is not only a methodological transition but an ethical priority in low-resource community research. Pushing frail, arthritic, or bedridden older adults to step onto standing scales or stand erect while in discomfort and pain can pose immediate safety risks, including loss of balance or physical falls, violate participants' comfort, and compromise data reliability. Localized anthropometric tape measurements, specifically Mid-Upper Arm Circumference (MUAC), Calf Circumference (CC), and Neck Circumference (NC), are simple, non-invasive, and can be conducted comfortably in a participant's household or in community settings.

Epidemiological studies across diverse Indian cohorts have validated MUAC as a sensitive marker for malnutrition and overall energy deficiencies (Das et al., 2018; Kshatriya et al., 2021). Also, NC is strongly correlated with central adiposity and cardiovascular risk factors and can assess upper-body fat distribution among older adults (Kroll et al., 2017; Sato et al., 2024). Additionally, unlike waist circumference, NC is less influenced by recent food intake, respiratory movements, abdominal distension, or clothing, making it particularly suitable for field-based assessments (Kroll et al., 2017; Sato et al., 2024). Although CC also serves as a reliable measure to assess metabolic risks and is closely correlated with advanced radiological scans in community-dwelling geriatric populations (Malik & Goel, 2024), it may not be feasible in severely frail older adults, particularly those aged 75 years and above, owing to the physical positioning and procedural requirements (Lee et al., 2018; Rose et al., 2022).

Furthermore, rural populations often have limited access to healthcare services and comprehensive nutritional assessment, necessitating simple, reliable, and low-cost screening tools that can be implemented at the community level by primary healthcare workers. Therefore, the present study aimed to evaluate the utility of MUAC

and NC as practical somatometric proxies for BMI among community-dwelling older adults in rural Delhi-NCR, India.

Methodology

Data source and sample

This cross-sectional study was conducted among community-dwelling older adults aged 60 years and above in the rural outskirts of Delhi-NCR. A total of 404 older adults were enrolled through convenience sampling. Participants who provided informed consent and underwent anthropometric assessment were included in the study. Individuals with acute illness or conditions that could substantially affect anthropometric measurements were excluded.

Data collection

Sociodemographic information, including age, sex, educational status, and socioeconomic status, was collected. Age was further categorized into young-old (60–74 years) and old-old (≥75 years).

Assessment of Somatometric Measurements

Height

Height was assessed by using the Anthropometer rod without any error margins.

Weight

Weight was measured using the Omron Karada Scan Body Composition Monitor HBF-375.

Body Mass Index (BMI)

BMI was calculated using the standard formula: BMI = Weight (kg) / Height (m^2). BMI categories were adjusted for Asian Indian populations as underweight (<18.5 kg/m²), normal weight (18.5–22.9 kg/m²), overweight (23.0–24.9 kg/m²), and obese (≥25.0 kg/m²), in accordance with WHO consensus guidelines to account for the South Asian "thin-fat" phenotype (Kalra et al., 2023).

Mid-upper Arm Circumference (MUAC), Neck Circumference (NC), and Calf Circumference (CC)

MUAC, NC, and CC were measured using the Cescorf anthropometric tape, approved by the International Society for the Advancement of Kinanthropometry (International Society for the Advancement of Kinanthropometry [ISAK], 2026). Standard procedures outlined in the International Standards for Anthropometric Assessment, 2019 (Ros et al., 2019) were followed while taking measurements. MUAC was taken as a measure of malnutrition (Goswami et al., 2022); Low CC as measure for higher metabolic risk (Malik & Goel, 2024) and is defined by using Asian Working Group for Sarcopenia (AWGS) cut-offs validated for older Indian adults (< 33 cm for women; < 34 cm for men) (Kalra et al., 2025).

Statistical analysis

The data were analyzed using Stata version 17 (StataCorp, College Station, TX, USA). Basic descriptive statistics were employed to present the baseline characteristics of the participants. Comparisons between males and females were performed using the independent samples t-test for continuous variables with normal distribution and the Chi-square test for categorical variables. Normality of continuous variables was assessed using the Shapiro-Wilk test. Spearman's rank correlation (ρ) was used because BMI was not normally distributed according to the Shapiro-Wilk test ($p < 0.001$). Statistical significance was defined as $\rho > 0.60$ and $p < 0.05$.

Ethical Considerations

Informed consent was obtained from all participants prior to data collection. Participants were informed of the study's purpose, the voluntary nature of participation, and their right to withdraw at any stage without consequence. This study forms part of a larger project awarded to the corresponding author and adheres to the Declaration of Helsinki, with ethical approval obtained from the Delhi University Institutional Human Ethics Committee (DU-IHEC; Ref. no. 4/DUNC/IHEC/SC/Jan/24).

Results

Table 1. Socio-demographic and anthropometric characteristics of the study participants according to sex (n=404).

Variables	Total Cohort (N=404)	Males (n=178)	Females (n=226)	*p-value
Socio-Demographic Features (Mean ± SD)				
Age (years), Mean ± SD	69.75 ± 7.93	70.88 ± 7.38	68.86 ± 8.24	0.011
Age Categories, n (%)				
60–74 years (Young-Old)	301 (74.50%)	127 (71.35%)	174 (76.99%)	0.196
75 years and older (Old-Old)	103 (25.50%)	51 (28.65%)	52 (23.01%)	
Education Level, n (%)				
No Formal Education	110 (27.23%)	10 (5.62%)	100 (44.25%)	<0.001
Primary / Secondary	257 (63.61%)	140 (78.65%)	117 (51.77%)	
Higher Education	37 (9.16%)	28 (15.73%)	9 (3.98%)	
Socioeconomic Status (SES), n (%)				
Low	124 (30.69%)	44 (24.72%)	80 (35.40%)	0.058
Middle	243 (60.15%)	118 (66.29%)	125 (55.31%)	
High	37 (9.16%)	16 (8.99%)	21 (9.29%)	
Anthropometric Profile				
Weight (kg) Mean ± SD	66.73 ± 13.07	67.59 ± 12.10	66.04 ± 13.79	0.248
Height (cm) Mean ± SD	161.17 ± 9.08	168.51 ± 6.51	155.21 ± 5.99	<0.001
Body Mass Index (kg/m²) Mean ± SD	25.77 ± 5.11	23.78 ± 3.99	27.38 ± 5.36	<0.001
Body Mass Index categories, n (%)				
Underweight (<18.5 kg/m²)	21 (5.20%)	10 (5.62%)	11 (4.87%)	<0.001
Normal (18.5–22.9 kg/m²)	107 (26.49%)	69 (38.76%)	38 (16.81%)	
Overweight (23.0–24.9 kg/m²)	53 (13.12%)	33 (18.54%)	20 (8.85%)	
Obese (≥25.0 kg/m²)	223 (55.20%)	66 (37.08%)	157 (69.47%)	
Mid-Upper Arm Circumference (MUAC) (cm), Mean ± SD	27.67 ± 4.07	26.70 ± 3.30	28.46 ± 4.46	<0.001
Neck Circumference (NC) (cm), Mean ± SD	35.42 ± 3.43	37.60 ± 3.00	33.67 ± 2.68	<0.001
Calf Circumference (cm) Mean ± SD	31.86 ± 3.96	31.92 ± 3.40	31.81 ± 4.37	0.777
Calf Circumference categories, n (%)				
Normal Calf Circumference	154 (38.12%)	55 (30.90%)	99 (43.81%)	0.008
Low Calf Circumference	250 (61.88%)	123 (69.10%)	127 (56.19%)	

Demographic Characteristics

The study represents the baseline cohort, which included 404 older adults, with a higher proportion of female participants (n = 226; 55.94%) than males (n = 178; 44.06%). The mean age of the overall cohort was 69.75±7.93 years, with males having a significantly higher mean age than females (70.88±7.38 vs. 68.86±8.24 years; p=0.011). The majority of the population fell into the young-old category of 60-74 years (n=301; 74.50%), followed by the old-old category of 75 years and older (n=103; 25.50%), with no statistically significant difference between the sexes. Educational status of the participants showed significant differences between sexes (p<0.001), with nearly half 44.25% of females having no formal education compared with only 5.62% of males, while higher education was more common among males (15.73% vs. 3.98%). Additionally, 60.15% of the cohort was observed to predominantly fall under the middle class of the socioeconomic status (SES), and the sex-wise distribution was not statistically significant.

Anthropometric Characteristics

Total mean body weight of the cohort was 66.73±13.07 kg, with no statistically significant difference between males and females (67.59±12.10 vs. 66.04±13.79 kg; p=0.248). Mean height for the cohort was 161.17±9.08 cm, with males significantly taller than females (168.51±6.51 vs. 155.21±5.99 cm; p<0.001). The average BMI of the total cohort was 25.77±5.11 kg/m^2, with females having a significantly higher mean BMI than males (27.38±5.36 kg/m^2 vs. 23.78±3.99 kg/m^2; p<0.001). Additionally, differences observed across BMI categories between sexes were statistically significant (p<0.001), with obesity being substantially more prevalent among females (69.47%) than males (37.08%), while normal BMI was more common among males (38.76% vs. 16.81%).

The mean MUAC for the entire cohort was 27.67 ± 4.07 cm, and females had a significantly larger MUAC than males (28.46 ± 4.46 vs. 26.70 ± 3.30 cm; p<0.001). Conversely, the mean NC was 35.42 ± 3.43 cm, with males exhibiting a significantly larger mean NC than females (37.60 ± 3.00 vs. 33.67 ± 2.68 cm, p<0.001). Moreover, the mean CC of the study sample was 31.86 ± 3.96 cm, with no statistically significant difference between male and female participants (31.92 ± 3.40 vs. 31.81 ± 4.37 cm; p=0.777). However, the prevalence of low CC was significantly higher among males (69.10%) than among females (56.19%; p = 0.008).

Table 2. Correlation Analysis between Neck Circumference (NC) and Body Mass Index (BMI) (n=380)

Variable Pair	Cohort Stratification	Sample Size (N)	Spearman's Correlation (ρ)	p-value
NC vs. BMI	Total Cohort	380*	0.267	**<0.001**
	By Sex			
	Males	170	0.740	**<0.001**
	Females	210	0.632	**<0.001**
	By Age category			
	60–74 years (Young-Old)	289	0.257	**<0.001**
	75 years and older (Old-Old)	91	0.327	**0.002**
*Due to missing data, 24 participants were excluded from correlation analysis.				

Table 2**.** The correlation analysis demonstrated a statistically significant positive association between NC and BMI across the study population. For the overall sample evaluated (n=380), NC showed a weak but significant positive correlation with BMI (ρ=0.267, p<0.001). When stratified by sex, the strength of this relationship increased markedly, with a strong positive correlation among males (ρ = 0.740, p < 0.001) and a moderately strong positive correlation among females (ρ = 0.632, p < 0.001). Age-stratified analysis also revealed significant positive correlations in both age groups. Among young-old participants (60-74 years; n = 289), NC was weakly correlated with BMI (ρ = 0.257, p < 0.001), while a slightly stronger correlation was observed in the old-old group (≥75 years; n = 91, ρ = 0.327, p = 0.002).

Table 3. Correlation between Calf Circumference (CC) and Mid-Upper Arm Circumference (MUAC), and Distribution of Low CC across Asian Indian BMI Categories (n=250).

Cohort Stratification	CC vs MUAC [ρ; p-value]	Prevalence of Low Calf Circumference across Asian Indian BMI categories, n (%)			
		Underweight BMI (<18.5 kg/m²)	Normal Weight BMI (18.5–22.9 kg/m²)	Overweight (23.0–24.9 kg/m²)	Obese (≥25.0 kg/m²)
Total Cohort with Low CC (N=250) *	ρ = 0.734; p < 0.001	21 (8.40%)	101 (40.40%)	44 (17.60%)	84 (33.60%)
Males (n=123)	ρ = 0.721; p < 0.001	10 (8.13%)	63 (51.22%)	26 (21.14%)	24 (19.51%)
Females (n=127)	ρ = 0.767; p < 0.001	11 (8.66%)	38 (29.92%)	18 (14.17%)	60 (47.24%)

*Refer to Table 1, the segregation of individuals based on CC.

Table 3. The analysis of participants with low CC (indicative of increased risk of sarcopenia; n = 250) showed a strong, statistically significant positive correlation between CC and MUAC across all BMI categories.

Within individuals having a low CC (N=250), a strong positive correlation was observed between CC and MUAC (ρ=0.734, p<0.001). Similarly strong positive correlations were observed in both males (ρ = 0.721, p < 0.001) and females (ρ = 0.767, p < 0.001), with the association slightly stronger in females. Tracking individuals with low CC (N=250) across Asian Indian BMI categories revealed that the largest proportion was in the normal-weight category (40.40%), followed by obese (33.60%), overweight (17.60%), and underweight (8.40%). Furthermore, among males with low CC (n=123), 51.22% had a normal BMI, whereas only 19.51% were obese. In contrast, among females with low CC (n=127), nearly half, 47.24%, were classified as obese, while 29.92% had a normal BMI.

Discussion

In this study, the higher proportion of older females reflects the 'feminization of aging' trend in India (International Institute for Population Sciences [IIPS], 2020). The distribution of the 'young-old' cohort (74.50%) is nearly uniform across both sexes and mirrors the national trend in the geriatric population (IIPS 2020; UNFPA, 2023). Epidemiologically, this concentration of individuals in the 'young-old' category highlights a vital public health window regarding screening of older adults for malnutrition and metabolic risks, enabling targeted clinical therapies before irreversible frailty in the old-old stage sets in (Kaur et al., 2025). Also, a significantly larger number of women were found to lack formal education compared to men, highlighting plausible reasons for the poor status of health literacy, dietary practices, healthcare utilization, clinical self-reporting, and delayed early diagnosis during field screenings among them (IIPS, 2020). Further, the uniform distribution of SES between both sexes reflects similar household-level economic conditions in the study population. However, the coexistence of predominantly low-to-middle SES and high female illiteracy may limit older women's financial autonomy, access to healthcare and nutritional resources, and increase their dependence on family members for geriatric care (UNFPA, 2023).

While the mean body weight remained virtually identical across both sexes, the sexual dimorphism in height, i.e., females being significantly shorter than males (about 13 cm), resulted in a significant disparity in BMI between the sexes. Because BMI is calculated as weight relative to the square of height, this structural baseline disparity resulted in 69.47% of females being categorized as obese, nearly double the 37.08% obesity observed in males. This observation aligns with previous studies reporting a higher prevalence of obesity among older women, attributable to postmenopausal hormonal changes, reduced physical activity, and increased fat deposition (Kaur et al., 2025). Furthermore, as vertebral compression and age-related osteoporotic changes result in a loss of standing height among older adults, inflated BMI calculations overestimate simple obesity statistics while strongly masking the underlying sarcopenic muscle wasting (Holt et al., 2023; Kaur et al., 2025). These findings reinforce the central inquiry of this study that BMI is an inappropriate screening tool for evaluating malnutrition and metabolic risks among older adults. Yet, similar findings are rarely reported in the scientific literature (Sperrin et al., 2016).

Additionally, over half of the total cohort was classified as obese based on BMI, yet 61.88% of these individuals simultaneously presented with low CC. Previous studies have established that low CC is an indicator of progressive muscle loss (sarcopenia) in older adults, and with aging, progressive muscle loss may coexist with increased adiposity, resulting in sarcopenic obesity (Malik & Goel, 2024). Consequently, a high BMI can mask this reduced muscle mass, classifying individuals as obese despite low muscle-to-fat ratios and elevated cardiometabolic risk (Malik & Goel, 2024; Singh & Chattopadhyay, 2024; Sperrin et al., 2016). This phenomenon of sarcopenic obesity indicates that relying purely on raw BMI thresholds can introduce critical biases while evaluating South-Asian geriatric populations (Singh & Chattopadhyay, 2024; Sperrin et al., 2016; Kaur et al., 2025).

Moreover, the significantly higher MUAC values observed in females were consistent with their elevated BMI and higher obesity prevalence, reinforcing the role of MUAC as a robust indicator of generalized adiposity in older females (Goswami et al., 2022). Conversely, CC categorizations based on AWGS cut-offs revealed a prevalence of underlying muscle wasting across the cohort, with more males affected. As traditional BMI metrics fail in accounting for the severe loss of muscle mass in aging populations, utilizing localized CC as a screening tool may offer an advantage by accurately capturing vulnerable individuals with higher metabolic risks who might otherwise appear misleadingly stable under standard BMI categories (Kalra et al., 2025; Srikrajang & Komolsuradej, 2024).

The sex-specific analysis revealed a significant association between NC and BMI, strengthening prior findings that NC may serve as a robust proxy for upper body adiposity and underlying cardiometabolic risks (Coelho et al., 2016; Kroll et al., 2017; Sato et al., 2024). Interestingly, this relationship was subject to Simpson's paradox, while pooled data showed no significant correlation between NC and BMI, sex-specific analyses revealed a strong positive correlation in both males and females (Simpson et al., 2010; Verma et al., 2017). The findings, thus, highlights the critical need for sex-stratified methodologies and tailored cutoffs in community health screenings to prevent diagnostic misclassification (Díaz et al., 2024; Kaur et al., 2025; Selvaraj et al., 2017). Also, as older adults experience height collapse due to age-related spinal disc degeneration and osteoporotic consequences, BMI becomes inflated and inaccurate (Holt et al., 2023). Because NC is independent of height, it

provides a stable, age-resilient measure that preserves diagnostic integrity while screening for metabolic risks associated with upper-body adiposity among older adults in community settings (Reyes-Perez et al., 2026).

A strong positive correlation between CC and MUAC across both sexes suggests that muscle wasting occurs systematically in both the upper and lower extremities in malnourished older adults (Kaur et al., 2025; Selvaraj et al., 2017). Tracking individuals with low CC across BMI categories yielded striking evidence and indicated the need to restructure screening protocols for the geriatric cohort to address metabolic risks. Surprisingly, only 8.40% of the individuals with low CC, indicating loss of muscle mass and underlying metabolic risks, were categorized as underweight by BMI. The vast majority (91.60%) were misclassified as normal weight (40.40%), overweight (17.60%), or obese (33.60%). This diagnostic inaccuracy was particularly evident in females, where 47.24% of those with low CC were categorized as obese. Because BMI fails to distinguish between loss of muscle mass and accumulation of fat mass, it obscures the hidden burden of sarcopenic obesity (Kalra et al., 2023; Kaur et al., 2025; Zhao et al., 2026). Hence, relying solely on BMI thresholds risks categorizing physically vulnerable older adults as low risk, excluding them from early intervention programs despite extreme muscle loss and high cardiometabolic risks.

Finally, these results demonstrate that localized tape measurement strategies, i.e., MUAC, CC, and NC, are viable alternatives to BMI for assessing malnutrition and underlying metabolic risks among older adults. Further research across diverse Indian cohorts is required to standardize these findings for use in screening frameworks for geriatric cohorts.

The primary strength of this study lies in demonstrating the severe limitations of BMI-based assessments among community-dwelling older adults in the selected population. Specifically, the study highlighted that BMI actively masks sarcopenic obesity and misclassifies individuals as ‘overweight’ and ‘obese’. Secondly, identification of Simpson’s paradox in the NC-BMI correlation revealed that while pooled data flattened the statistical correlation, sex-based stratification revealed a strong and significant association between NC and BMI. Finally, by validating simple tape measurements, this study provides a practical, real-world solution for using MUAC and NC as highly reliable screening tools for assessing malnutrition and metabolic risks among resource-limited, community-based geriatric populations. However, several limitations must be acknowledged. First, the study design is cross-sectional and therefore cannot establish the causal relationship between adiposity and age-related loss in muscle mass. Second, due to resource constraints in community settings, localized muscle mass and fat distribution could not be validated using more advanced diagnostic tools such as Dual-Energy X-ray Absorptiometry (DEXA). Third, the sample was collected from a peri-urban region of Delhi-NCR, where the influence of cultural and traditional factors was not fully assessed, hence, the generalizability of these findings to a broader population may be limited.

Conclusions

This study revealed that continuing to rely solely on traditional BMI thresholds for health screening of the geriatric population actively misclassifies older adults by hiding the severe loss of muscle mass. Also, it provides an actionable solution by demonstrating that using localized tape measurements, specifically MUAC and NC as screening tools for assessment of malnutrition and metabolic risks among older adults, is better, more affordable, and more reliable than BMI. It is recommended that the public health and healthcare infrastructure should transition to integrated tape-based protocols for geriatric assessments to identify, track, and treat vulnerable older adults before irreversible conditions set in with advancing age.

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Author Contribution

Nirmal Nath Upadhyay: Writing Original Draft, Conceptualization, Data collection and Curation, Formal Analysis, Visualization; Shromona Das: Writing Original Draft, Conceptualization, Data collection and Curation, Formal Analysis, Visualization; Shivani Chandel: Funding Acquisition, Conceptualization, Validation, Resources, Methodology, Investigation, Writing Review & Editing, Supervision. All the authors have read and approved the final version of the manuscript.

Ethical Consideration

Informed consent was obtained from all participants prior to data collection. Participants were informed of the study's purpose, the voluntary nature of participation, and their right to withdraw at any stage without consequence. This study forms part of a larger project awarded to the corresponding author and adheres to the Declaration of Helsinki, with ethical approval obtained from the Delhi University Institutional Human Ethics Committee (DU-IHEC; Ref. no. 4/DUNC/IHEC/SC/Jan/24).

Availability of data and material

The data will be made available by the corresponding author upon reasonable request.

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Informed Consent Statement

All the participants included in the study provided written informed consent.

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