Overlap and Determinants of Sarcopenia and Frailty among Rural and Urban Community-Dwelling Older Adults in Doiwala Block, Dehradun, Uttarakhand: A Cross-Sectional Study

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Abstract

Background: Frailty and sarcopenia are two separates but closely related geriatric diseases that hasten death, institutionalization, and functional deterioration. There is a dearth of community-based comparison data between rural and urban older adults in sub-Himalayan regions, despite the impact being highlighted in worldwide literature. **Material and Methods:** A community-based cross-sectional study was conducted among 210 elderly adults selected via multistage random sampling with probability proportional to size (PPS). The Asian Working Group for Sarcopenia (AWGS) 2019 consensus was used to classify sarcopenia. Frailty was measured using the Tilburg Frailty Indicator (TFI; cut off $\geq$ 6). The Mini Nutritional Assessment-Short Form (MNA-SF) was used to assess nutritional status, and Lawton's Instrumental Activities of Daily Living (IADL) scale and the Katz Index of Activities of Daily Living (ADL) were used to assess functional impairment. **Results:** The overall prevalence of frailty was 62.9% (n=132), with no statistically significant urban - rural difference (60.0% vs 65.7%, p=0.310). Diagnosed sarcopenia (confirmed or severe) was identified in 46.7% (n=98) of participants, while 40.0% (n=84), met the screening criteria for possible sarcopenia. Advanced sarcopenia stages were significantly more prevalent in rural settings (44.7% confirmed and 11.4% severe) compared to urban areas (29.5% confirmed and 7.6% severe; $p < 0.001$). Concomitant frailty and sarcopenia were observed in 58.1% (n=122) of participants. Multivariable logistic regression revealed that living with family, polypharmacy, at-risk poor nutritional status, ADL dependency, and IADL dependency were independently associated with frailty. **Conclusions:** Sarcopenia and frailty are highly prevalent and closely linked among community-dwelling older adults in North India.

Key-words: Frailty; Sarcopenia; AWGS 2019; Tilburg Frailty Indicator; Mini Nutritional Assessment-Short Form; Katz Index of Activities of Daily Living

Introduction

Global populations are experiencing a rapid demographic transition marked by progressive population aging. With advancing age, individuals experience a gradual attenuation of multisystem physiological reserve, resulting in diminished resilience against acute and prolonged medical stressors.[1,2] Frailty and sarcopenia are two key interrelated geriatric giants at the edge of this physiological decline.[3] A loss of physiological, psychological, and social reserves is the hallmark of frailty, which is defined as a multifaceted dynamic state.[4] Modern geriatric paradigms acknowledge that frailty is a more comprehensive, holistic construct that includes cognitive decline, anxiety, mood disorders, and the depletion of social support networks,[4]whereas early phenotypic models concentrated almost exclusively on physical characteristics like inadvertent weight loss and fatigue.[3]

According to extensive epidemiological studies, such as the Longitudinal Ageing Study in India (LASI) Wave-1, 14.5% of older persons in the sub-Himalayan state of Uttarakhand have physical frailty.[5] Simultaneously, age-related loss of muscle mass, muscle strength, and athletic performance is the hallmark of sarcopenia, a unique skeletal muscle illness.[6,7] Standardized diagnostic methods for Asian populations have been established by the Asian Working Group for Sarcopenia (AWGS 2019), with a focus on early screening using anthropometric proxies, followed by functional battery tests and confirmation handgrip strength.[8] Falls, limited mobility, and physical dependence are all directly caused by sarcopenia, which is a major structural and physical cause of frailty.[9] Recent investigations across diverse Indian settings highlights sarcopenia as a major public health challenge.

Sarcopenia and frailty, despite their clinical differences, have similar pathophysiological mechanisms, including oxidative stress, hormone dysregulation, persistent low-grade inflammation, and malnutrition.[10,11] Sub-Himalayan regions like Dehradun present a unique environment where rural terrain

demands lifelong, high-intensity physical labour alongside seasonal dietary shortages, while urban areas experience rapid lifestyle shifts toward physical inactivity coupled with processed food consumption.[1,2] Comparing these two populations provides novel insights into how opposing environmental stressors drive sarcopenia progression and frailty multi-system decline.[1,2]

Thus, the three main objectives of this community-based study were to:

1. Ascertain and compare the prevalence and severity of frailty and sarcopenia between rural and urban elderly populations residing in Doiwala block, Dehradun.
2. Systematically identify the clinical, nutritional, and sociodemographic risk factors associated with these conditions.
3. Assess the combined impact of their co-existence on basic activities of daily living (ADL) and instrumental activities of daily living (IADL).

Materials and Methods

Study Design, Setting, and Period: A community-based, observational, cross-sectional study was conducted over a period of six months within the rural and urban catchment areas of Doiwala Block, located in the Dehradun district of Uttarakhand, India.

Sample Size Calculation: The sample size was determined based on the 14.5% regional prevalence of frailty reported in the LASI Wave-1 report for Uttarakhand.[5] The sample size was calculated using the standard formula: n = Z2.p.q/d2

Where Z = 1.96 (for a 95% confidence interval), p = 0.145 (prevalence), q = 1 - p = 0.855, and d = 0.06 (absolute margin of error chosen at 6%). This yielded an initial sample size of approximately 133. To account for the multistage cluster design and potential variances across urban/rural strata, a design effect of 1.5 was applied, increasing the required sample to 200. Factoring in an anticipated non-response rate of 5%, the final calculated sample size was 210 participants, allocated equally as 105 rural and 105 urban older adults.

Sampling Strategy: A multistage random sampling technique was utilized to eliminate selection bias. In the first stage, out of six administrative blocks, Doiwala block comprising of 75 villages and 20 urban wards was selected using convenience sampling. In the second stage, applying a 10% sampling rule, 8 rural villages and 2 urban wards were randomly selected using the lottery method. An equal allocation strategy (50:50) was implemented at primary stratum level, assigning 105 participants each to rural and urban cohort. Within each stratum, probability proportional to size (PPS) sampling was applied across selected villages and wards. In each selected village and ward, a house to house survey was conducted using a systematic clock wise direction, starting from a central landmark. If a household had more than one elderly, one participant was randomly selected by lottery method. If an eligible residents refused or was unavailable after 2 repeated visits, adjacent household was approached (Fig. 1).

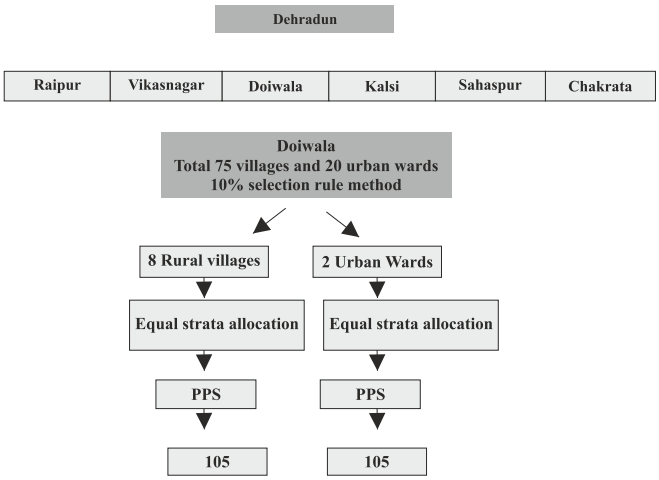


Fig 1. Multistage Sampling

Inclusion and Exclusion Criteria

- Inclusion Criteria: Individuals aged 60 years and above, who were permanent residents of the selected villages or wards for at least one year, and who voluntarily provided written informed consent.
- Exclusion Criteria: Individuals who were completely bedridden, possessed severe physical deformities or advanced musculoskeletal trauma preventing physical performance testing or were critically ill at the time of the survey.

Data Collection Tools and Measurements.

Data collection was conducted by 2 trained researchers. Prior to study initiation, training was conducted. Inter rater reliability demonstrated high agreement for handgrip dynamometer readings (ICC =0.88) and Short Physical Performance Battery (SBPP) (ICC =0.86). All the study instruments underwent standard forward - backward translations into Hindi by the investigators and pilot tested on 20 elderly individuals for clarity, feasibility and internal consistency (Cronbach's α = 0.81 and 0.79 for TFI and MNF -SF respectively).

Socio-Demographic and Clinical Profiles: Data were collected using a structured, interviewer-administered questionnaire covering age, gender, educational status, marital status, and living arrangements. Socioeconomic status (SES) was classified using the Modified BG Prasad Socioeconomic Scale (updated for 2024 index values: Class I: ≤ Rs. 9130; Class II: Rs. 4565-9129; Class III: Rs. 2739-4564;

Class IV: Rs. 1369-2738; and Class V: <Rs. 1369). Clinical data included the number of chronic co-morbidities, history of falls (past 12 months), and polypharmacy status (≥ 5 regular medications).

Multi-Dimensional Frailty Assessment: Frailty was quantified using the Tilburg Frailty Indicator (TFI), evaluating 15 items across three domains[8,12]: Physical (8 items), Psychological (4 items), and Social (3 items). A cut-off score of ? 6 was applied to classify individuals as "Frail.

Sarcopenia Diagnostic Framework: Sarcopenia was diagnosed in accordance with the Asian Working Group for Sarcopenia (AWGS 2019) consensus guidelines,[7] using a sequential three-tiered assessment:

1. Screening/Proxy Muscle Mass Assessment: Mid-Upper Arm Circumference (MUAC < 23 cm for males, < 22 cm for females) and Calf Circumference (CC < 35 cm for males, < 33 cm for females).
2. Muscle Strength Quantification: Handgrip strength via Jamar/DHULI hydraulic hand dynamometer. Low muscle strength was defined using the Asian consensus cut-offs of < 28 kg for men and < 18 kg for women.
3. Physical Performance Evaluation: Short Physical Performance Battery (SPPB), which combines evaluations of standing balance, gait speed over a 4-meter course, and a timed five-times chair-stand test. An SPPB score of ≤ 9 or a standalone gait speed of < 0.8 m/s denoted low physical performance.

Participants were then stratified into four mutually exclusive categories: No Sarcopenia, Possible Sarcopenia, Confirmed Sarcopenia, Severe Sarcopenia

Nutritional and Functional Assessment: Mini Nutritional Assessment-Short Form (MNA-SF; maximum score 14).[9] Scores 12-14: Normal; 8-11: At risk of malnutrition; 0-7: Malnourished.

Basic Activities of daily living (ADL): Katz Index of ADL (bathing, dressing, toileting, transferring, continence, feeding).[10] Katz score < 6 indicated basic ADL dependency.

Instrumental Activities of Daily Living (IADL): Lawton's IADL Scale (telephone use, shopping, food preparation, housekeeping, laundry, mode of transportation, medication responsibility, handling finances).[11] Scores < 8 (for women) or < 5 for men indicated IADL dependency.

Statistical Analysis: Data were analysed using SPSS Version 27.0.[12] Continuous variables were expressed as mean and standard deviation (SD), and categorical variables were presented as absolute frequencies and percentages Bivariate associations between socio-demographic/clinical parameters and the primary outcomes (frailty status and sarcopenia severity) were evaluated using Pearson's Chi-Square (X2) test or Fisher's Exact test wherever appropriate.

Variables demonstrating a p-value <0.10 in the univariate analysis were selected for a multivariable binary logistic regression model to isolate independent predictors of frailty. Multicollinearity among predictors was checked using Variance Inflation Factor (VIF) diagnostics; all VIF values ranged between 1.12 and 1.84, confirming no collinearity issues. Crude and Adjusted Odds Ratios with their corresponding 95% Confidence Intervals (CI) were calculated. To preserve statistical power and prevent model over-fitting, sarcopenia was entered as a binary covariate (Absent vs. Present). Statistical significance across all tests was set a priori at $p < 0.05$.

Ethical Considerations: Ethical clearance was obtained from the Institutional Ethics Committee of the University (SRHU/HIMS/Ethics/2025/261 dated 04.07.2025). Written informed consent was obtained from all the participant prior to enrolment. For participants with moderate cognitive impairment, written proxy consent was taken from caregiver along with participant assent.

Results:

A total of 224 elderly individuals were approached across 8 rural villages and 2 urban wards. Of these, 14 individuals declined participation (refusal rate =5.9%). The final study enrolled 210 older adults, consisting of 101 (48.1%) males and 109 (51.9%) females, balanced equally between rural (n=105) and urban (n=105) residences. Complete data were obtained from all 210 participants. The mean age of the cohort was 70.8 ± 8.2 years.

Socio-demographic analysis revealed that 72.4% of the participants had either no formal education or primary schooling only, a trend that was more pronounced in rural areas (83.8%) than in urban sectors (60.9%; p=0.008). Polypharmacy was significantly higher in rural participants (44.7%) than in urban participants (23.8%, p=0.002). The baseline sociodemographic and clinical features are shown in Table 1.

Table 1: Baseline Socio demographic and clinical characteristics (N=210).

Variable	Total sample (n =210) %	Urban (n=105) %	Rural n=105) %	p- value
Age group (Years)				
60-69	107 50.9	59 56.2	48 45.7	0.141
70-79	63 30.0	25 23.8	38 36.2	
≥ 80	40 19.1	21 20.0	19 18.1	

Gender				
Male	101 48.1	51 48.6	50 47.6	0.89
Female	109 51.9	54 51.4	55 52.4	
Education level				
No formal/Primary	152 72.4	64 60.9	88 83.8	0.008
Lower Secondary	41 19.5	26 24.8	15 14.3	
Upper secondary/ Graduate	17 8.1	15 14.3	2 1.9	
Socio Economic Status (BG Prasad 2024)				
Class I (≥ Rs 9130)	75 35.7	40 38.1	35 33.3	0.781
Class II (Rs 4565- 9129)	89 42.4	44 41.9	45 42.9	
Class III (Rs 2739 – 4564)	46 21.9	21 20.0	25 23.8	
Marital status				
Married	119 56.6	62 59.0	57 54.3	0.491
Widowed/single	91 43.4	43 41.0	48 45.7	
Living Arrangement				
Living with family	156 74.3	74 70.5	82 78.1	0.312
Living with spouse only	45 21.4	27 25.7	18 17.1	
Living alone	09 4.3	4 3.8	5 4.8	
Clinical parameters				
≥ 1 Chronic morbidity	115 54.7	55 52.3	60 57.1	0.488
Polypharmacy (≥ 5 drugs)	72 34.2	25 23.8	47 44.7	0.002
History of falls (past year)	83 39.5	41 39.0	42 40.0	0.885

The overall prevalence of multi-dimensional frailty (TFI ≥ 6) was 62.9% (n=132). Although frailty rates were slightly higher among rural residents (65.7%, n=69) than urban residents (60.0%, n=63), this difference did not reach statistical significance (X2= 0.722, p = 0.310). The application of the AWGS 2019 diagnostic framework revealed an overall sarcopenia prevalence of 86.7%: 40.0% (n=84) had possible sarcopenia, 37.1% (n=78) had confirmed sarcopenia, and 9.6% (n=20) had severe sarcopenia. Sarcopenia severity was strongly associated with place of residence (X2 = 16.14, p = 0.001). Urban older adults had predominantly early-stage, "possible" sarcopenia (53.3%), whereas rural older adults had significantly higher rates of advanced stages, with confirmed (44.7%) and severe (11.4%) sarcopenia driving the rural burden. These are summarized in Table 2.

Table 2: Prevalence and Severity of Frailty and Sarcopenia stratified by residence.

Geriatric Syndrome	Total cohort n = 210 %	Urban sector n= 105 %	Rural sector n = 105 %	X^2 /p -value
Frailty Status (TFI)				
Robust (< 6)	78 37.1	42 40.0	36 34.3	X2 = 0.722 p = 0.310
Frail (≥ 6)	132 62.9	63 60.0	69 65.7	
Sarcopenia (AWGS – 2019)				
No sarcopenia	28 13.3	10 9.5	18 17.1	X^2 = 16.14 p < 0.001
Possible Sarcopenia	84 40.0	56 53.3	28 26.7	
Confirmed Sarcopenia	78 37.1	31 29.5	47 44.7	
Severe Sarcopenia	20 9.6	8 7.6	12 11.4	

Univariate analysis identified several factors associated with frailty. Increasing age was strongly associated with frailty, with rates rising from 40.2% in the 60-69 age group to 87.5% in those aged > 80 years (p<0.001). Other significant factors included lower educational status (p=0.008), being widowed (p=0.011), and living with family (p=0.008). Clinical and functional indicators, including chronic co-morbidities (p=0.027), abnormal nutritional profiles (p=0.001), basic ADL dependency (p<0.001), and instrumental IADL dependency (p<0.001), were also strongly associated with frailty as detailed in Table 3.

Table 3: Univariate Associations with Multidimensional Frailty.

Variable	Category	Frail (n=132)	Robust (n=78)	X^2	p-value
Age Group	60–69 years	43 (40.2%)	64 (59.8%)	49.32	<0.001
	70–79 years	54 (85.7%)	9 (14.3%)		
	≥ 80 years	35 (87.5%)	5 (12.5%)		
	No formal / Primary	100 (65.8%)	52 (34.2%)		

Education	Lower secondary	18 (43.9%)	23 (56.1%)	9.61	0.008
	Upper secondary / Graduation	14 (82.4%)	3 (17.6%)		
Marital Status	Married	70 (58.8%)	49 (41.2%)	6.43	0.011
	Widowed	62 (68.1%)	29 (31.9%)		
Living Arrangement	Alone	5 (55.6%)	4 (44.4%)	9.65	0.008
	With Spouse	21 (46.7%)	24 (53.3%)		
	With Family	106 (67.9%)	50 (32.1%)		
Comorbidities	Yes	80 (69.6%)	35 (30.4%)	4.86	0.027
	No	52 (54.7%)	43 (45.3%)		
ADL Status	Dependent (< 6)	65 (90.3%)	7 (9.7%)	35.81	<0.001
	Independent (= 6)	67 (48.6%)	71 (51.4%)		
IADL Status	Dependent	89 (76.7%)	27 (23.3%)	21.03	<0.001
	Independent	43 (45.7%)	51 (54.3%)		
Nutritional Status (MNA-SF)	Normal (12–14)	38 (48.1%)	41 (51.9%)	11.45	0.001
	Poor / At Risk (0–11)	94 (71.8%)	37 (28.2%)		

Multivariable binary logistic regression was performed using frailty as the dependent variable and entering all statistically significant covariates from the univariate analysis. Living with family/spouse, polypharmacy, presence of sarcopenia, ADL dependency, IADL dependency, and poor nutritional status remained independently associated with frailty in the final model, whereas chronological age and comorbidities was not statistically significant. The complete regression model is presented in Table 4.

Table 4: Multivariable Logistic Regression Analysis of Predictors for Frailty

Predictive Variable	Category	Crude OR (95% CI)	p-value	Adjusted OR (95% CI)	p-value
Age Group	≥ 80 years	Reference	—	Reference	—
	Under 80 years	0.19 (0.07–0.50)	0.001	0.69 (0.20–2.20)	0.546
Living Arrangement	Alone	Reference	—	Reference	—
	With Family/Spouse	2.25 (0.92–5.50)	0.07	4.03 (1.15–14.09)	0.029
Comorbidities	No	Reference	—	Reference	—
	Yes	1.89 (1.07–3.33)	0.028	2.07 (0.98–4.38)	0.058
Polypharmacy	No	Reference	—	Reference	—
	Yes (≥ 5 drugs)	1.22 (0.68–2.20)	0.49	2.26 (1.01–5.08)	0.047
Sarcopenia status	Absent	Reference	—	Reference	—
	Present	2.10 (1.10-4.21)	<0.018	2.45 (1.12 - 5.38)	0.024
ADL Status	Independent	Reference	—	Reference	—
	Dependent	9.80 (4.35–22.10)	<0.001	9.09 (3.23–25.01)	<0.001
IADL Status	Independent	Reference	—	Reference	—
	Dependent	3.91 (2.16–7.07)	<0.001	4.17 (2.05–8.48)	<0.001
Nutritional Status (MNA-SF)	Normal	Reference	—	Reference	—
	Poor / At Risk	2.78 (1.54–5.00)	0.001	3.03 (1.47–6.25)	0.003

(Model Metrics: Omnibus Chi-square = 79.23, $p < 0.001$; Nagelkerke $R^2 = 0.429$; Hosmer-Lemeshow Goodness-of-Fit Chi-square = 13.68, $p = 0.090$; ROC AUC = 0.84

To evaluate the combined impact of these syndromes on functional independence, participants were grouped into four categories based on the presence of frailty only, sarcopenia only, both, or neither. The co-occurrence of both syndromes was associated with the highest rates of functional dependency, with 67.2% of comorbid individuals presenting with IADL dependency and 47.5% presenting with ADL dependency scores as detailed in Table 5.

Table 5: Combined Functional Impact of Sarcopenia and Frailty

Clinical Group	ADL Independent	ADL Dependent	IADL Independent	IADL Dependent	Total
Neither Syndrome	18 (100.0%)	0 (0.0%)	13 (72.2%)	5 (27.8%)	18
Frailty Only	3 (30.0%)	7 (70.0.0%)	3 (30.0%)	7 (70.0.0%)	10
Sarcopenia Only	53 (88.3%)	7 (11.7%)	38 (63.3%)	22 (36.7%)	60
Both Syndromes	64 (52.5%)	58 (47.5%)	40 (32.8%)	82 (67.2%)	122
Total	138 (65.7%	72 (34.3%)	94 (44.8%)	116 (55.2%)	210
p-value	<0.001	—	<0.001	—	—

Discussion

The study evaluated the prevalence, severity distribution and clinical determinants of sarcopenia and multidimensional frailty in urban and rural settings of Doiwala block, Dehradun.

Our findings demonstrate that multidimensional frailty and sarcopenia are widespread among older adults in North India, with 46.7% diagnosed with sarcopenia and 40.0% identified with possible sarcopenia.

The LASI Wave-1 report for Uttarakhand revealed a regional baseline of 14.5%, which is lower than the measured frailty prevalence of 62.9%.[5] This discrepancy is primarily methodological. LASI employed a public health physical phenotype model.[2,3] In contrast our study utilized the multidimensional Tilburg Frailty Indicator (TFI), which incorporates physical, psychological, and social domains.[2,8] By capturing early cognitive changes, mood disturbances and social isolation, the TFI identifies broader biological and psychosocial vulnerability. Our findings align with multidimensional frailty estimates reported by Dasgupta et al. in West Bengal (44.3%),[3] Kumar et al. in a corresponding tertiary sub-Himalayan environment[14] and Kendhapedi & Devasenapathy in South India (57.8%).[15]

A key finding is the distinct rural - urban pattern of sarcopenia severity. Whereas sarcopenia was prevalent in both environments overall, older persons in rural areas had far greater rates of advanced phases, such as confirmed (44.7%) and severe (11.4%) sarcopenia, whereas those in urban areas were more likely to have early-stage, "possible" sarcopenia (53.3%). This shift can be explained by lifestyle and environmental variables.[2] Rural elderly individuals in sub-Himalayan regions frequently undertake strenuous agricultural manual labour without sufficient dietary protein or calorie intake, accelerating mechanical muscle wear and catabolism. Additionally, seasonal food insecurity and limited access to health care in rural areas can allow early muscle weakness to progress to severe muscle wasting.[1,2] Similar rural - urban sarcopenia gradients in Indian populations have been documented by Rao et al and Bhat et al. [16,17]

Our multivariable logistic regression model isolated five clear independent predictors:

1. Living with Family/Spouse: (AOR = 4.03): Older persons living in extended family structures may fall into a "social dependency trap" where families overmanage the individual, hastening disuse muscle atrophy.[2]
2. Polypharmacy: (AOR = 2.26): Regular consumption of ? 5 drugs more than doubled frailty risk, reflecting multimorbidity and adverse drug reactions.[2,12]
3. Sarcopenia (AOR =2.45): The presence of sarcopenia independently increased frailty risk, highlighting the role of skeletal muscle as a key physical component of broader frailty.[2]
4. Nutritional Status: (AOR = 3.03): Malnutrition directly fuels muscle loss, physical weakness, and reduced immune function, accelerating frailty.[2,9]
5. Functional Dependencies (ADL (AOR = 9.09) and IADL Dependency (AOR = 4.17): Loss of autonomy in daily activities serves as a primary marker of advanced multi system decline.[2,10,11]

Conclusion

This study shows that among older persons living in the community in Dehradun, sarcopenia and frailty are quite prevalent and have a significant clinical overlap. While multi-dimensional frailty affects both urban and rural populations, sarcopenia manifests more severely in rural settings. The findings that frailty is more accurately predicted by nutritional status, polypharmacy, and functional reliance than by chronological age. These results demonstrate that integrated models of care such as those recommended in the WHO Integrated Care for Older People (ICOPE) guidelines and demonstrated by Bhaskaran et al. are much needed to prevent functional dependence in community dwelling older adults.[18,19]

Recommendation

Community screening using calf circumference and TFI should be integrated into routine primary care under the National Programme for Health care of the Elderly (NCHPE). [7,8,20] Public health programs in sub-Himalayan regions should prioritize nutritional supplementation, resistance program exercise and medication reviews to address polypharmacy.

Limitations

The cross-sectional design makes it impossible to determine the exact cause of the temporal association between risk factors, sarcopenia and frailty. Since this study was conducted in single administrative block of Dehradun district, the findings may not be generalizable to entire state of Uttarakhand or sub-Himalayan regions. Other limitation of the study was use of muscle mass using validated anthropometric proxies rather than advanced imaging modalities such as DXA or BIA, since they are often impractical for community-based surveys. Conceptual overlap between frailty and ADL/IADL functional dependencies may introduce circularity i.e., potential reverse causality.

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