

Original Research Article

Sociodemographic, behavioural and cardiometabolic correlates of severe locomotive syndrome among older adults attending an urban health training centre in Maharashtra: a facility based cross-sectional study

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ABSTRACT

Background: Severe Locomotive Syndrome (severe LS) is an emerging public health concern that affects functional independence among older adults. Evidence on its sociodemographic, behavioural, and cardiometabolic correlates in India remains limited. This study aimed to identify correlates of severe LS among older adults attending an urban health training centre in Maharashtra.

Methods: A facility-based cross-sectional study was conducted among 264 adults aged ≥ 60 years. Sociodemographic, behavioural, and cardiometabolic data were collected using a structured questionnaire. LS was assessed using the Stand-Up Test, Two-Step Test, and the 25-item Geriatric Locomotive Function Scale (GLFS-25). Participants were categorised as non-severe LS (LS-1/LS-2) or severe LS (LS-3). Associations were examined using Pearson's chi-square test and the Mann-Whitney U test. Multivariable logistic regression and dose-response trend analyses were performed, and model performance was evaluated.

Results: The median age of participants was 70 years (IQR: 66–74), and 57.6% were female. Severe LS was observed in 55.3% of participants. Independent correlates of severe LS included age ≥ 70 years, female gender, non-graduate educational status, history of falls, smoking, central obesity, and hyperlipidaemia. The odds of severe LS increased significantly with the number of cardiometabolic disorders (score test for trend, $p < 0.001$). The model demonstrated good fit (Hosmer–Lemeshow $p = 0.238$) and good discriminatory ability (AUC=0.89).

Conclusions: Severe LS affected more than half of the study participants and was significantly associated with advancing age and several modifiable risk factors. These findings highlight the need for early screening and targeted interventions to promote healthy ageing among urban older adults.

Keywords: Analytical cross-sectional, Anthropometric assessment, Cardiometabolic health, Geriatrics, Healthy ageing, Locomotor system

INTRODUCTION

Global demographic transition has brought ageing to the forefront of public health priorities. The world population aged 60 years and above is projected to reach 2.1 billion

by 2050, rising from approximately 1 billion in 2020.¹ India is experiencing a particularly rapid ageing trajectory; the older adult population is expected to exceed 319 million by 2050, up from 103 million in 2011.^{2,3} While increased longevity reflects improvements

in healthcare and living standards, ageing is invariably accompanied by declining physical function, increased dependency and a rising burden of non-communicable disease.^{1,4,5} Locomotive syndrome (LS), first conceptualized by the Japanese Orthopedic Association in 2007, is defined as a state of reduced mobility arising from impairment of the locomotive organs such as bones, muscles, joints and nervous system with an attendant risk of requiring long-term care.⁶⁻⁸

LS is classified into three progressive stages: LS-1 (mild), LS-2 (moderate) and LS-3 (severe). Severe LS (LS-3) is of particular clinical relevance as it demarcates the threshold for significant loss of functional independence, pronounced deterioration in health-related quality of life and a high requirement for formal care services.^{8,9} Although LS was originally characterized within Japanese populations, its relevance to India's rapidly ageing urban population is increasingly recognized. The relationship between cardiometabolic disorders and LS is biologically plausible and mechanistically well-supported. Chronic conditions such as hypertension, diabetes mellitus and hyperlipidaemia promote systemic low-grade inflammation, which accelerates skeletal muscle protein catabolism (sarcopenia), impairs neuromuscular function and reduces bone mineral density. Vascular compromise associated with atherosclerosis and microvascular disease further reduces oxygen and nutrient delivery to musculoskeletal tissues, contributing to muscle weakness and reduced physical performance.

Additionally, adipose tissue dysfunction in centrally obese individuals generates pro-inflammatory adipokines that exacerbate muscle wasting and joint inflammation.¹⁰⁻¹³ These pathways collectively predispose older adults with cardiometabolic multimorbidity to more severe locomotive dysfunction. Although evidence on the prevalence of locomotive syndrome in India is emerging, the prevalence and determinants of severe locomotive syndrome have not been adequately examined.^{10,14} This gap is particularly relevant in the Indian context, where rapid urbanization has led to a rising burden of cardiometabolic multimorbidity among older adults, which may further influence the severity of locomotive syndrome.^{15,16}

The present study was therefore undertaken to assess the sociodemographic, behavioural and cardiometabolic correlates of severe locomotive syndrome among older adults attending an urban health training centre in Maharashtra.

METHODS

Study design and setting

A facility-based cross-sectional study was conducted in November 2025 at the outpatient department of an Urban

Health Training Centre located in Bandra East, Maharashtra.

Sample size and sampling technique

In the absence of prior Indian studies reporting the prevalence of severe locomotive syndrome or its associated predictors, a formal prevalence-based or predictor-based sample size estimation was not feasible. All older adults aged ≥ 60 years attending the outpatient department of the Urban Health Training Centre during the study period were approached and screened for participation in the study. Of the 317 individuals screened, 309 met the inclusion criteria, of whom 264 provided written informed consent and were enrolled in the study.

The adequacy of the sample for multivariable logistic regression analysis was evaluated using the events-per-variable (EPV) criterion. The final model included 11 independent variables and 146 participants with severe LS, yielding an EPV ratio of 13.3, which exceeded the recommended minimum threshold of 10 and indicated adequate sample size for reliable model estimation.

A non-probability convenience sampling technique was used to recruit study participants.

Inclusion criteria and exclusion criteria

Individuals aged 60 years and above were eligible for inclusion in the study. The use of ambulatory aids and inability to perform functional tests were not considered exclusion criteria, as excluding such individuals could have resulted in underrepresentation of participants with severe locomotive syndrome.

Individuals with severe hearing or speech impairment were excluded if the impairment, as determined by the investigator during the initial screening, precluded effective communication, provision of informed consent, or collection of the information required for the study.

Data collection

Data were collected using a predesigned, pretested, structured questionnaire to obtain information on age, gender, religion, marital status, educational status, history of falls, alcohol use and smoking history. History of falls referred to at least one self-reported fall during the preceding 12 months. Alcohol use was defined as self-reported current or past alcohol consumption. Smoking history was defined as self-reported current or past regular smoking of tobacco products.

Information on previously diagnosed hypertension, diabetes mellitus and hyperlipidaemia was obtained through participant self-report and cross-verified using available outpatient medical records. Anthropometric measurements including height, weight, waist

circumference and hip circumference were obtained using standardised techniques and calibrated instruments. Body mass index (BMI) was calculated as weight in kilograms divided by height in metres squared (kg/m^2) and dichotomized into $<23 \text{ kg/m}^2$ and $\geq 23 \text{ kg/m}^2$ with the latter category representing overweight and obese individuals according to Asian cut-off values.¹⁷ Central obesity was assessed using waist–hip ratio (WHR), defined as ≥ 0.85 for women and ≥ 0.90 for men, based on standard criteria.¹⁸

Assessment of locomotive syndrome

Locomotive syndrome was assessed using a combination of functional performance tests and a validated questionnaire, including the Two-Step Test, the Stand-Up Test and the 25-item Geriatric Locomotive Function Scale (GLFS-25).^{19–23} Based on established cut-off values, participants were categorized into four groups. Non-locomotive syndrome (non-LS) was defined by a Two-Step Test score of ≥ 1.3 , a Stand-Up Test score of 5–8 and a GLFS-25 score of 0–6. Locomotive syndrome stage 1 (LS-1) was defined by a Two-Step Test score of 1.1–1.2, a Stand-Up Test score of 3–4 and a GLFS-25 score of 7–15. Stage 2 locomotive syndrome (LS-2) was defined by a Two-Step Test score of 0.9–1.0, a Stand-Up Test score of 2 and a GLFS-25 score of 16–23. Stage 3 locomotive syndrome (LS-3) was defined by a Two-Step Test score of <0.9 , a Stand-Up Test score of 0–1 and a GLFS-25 score of 24–100, indicating severe disease.^{9,24–26} According to standard staging criteria, LS-1, LS-2 and LS-3 represent mild, moderate and severe locomotive syndrome, respectively. The stage of locomotive syndrome for each participant was determined using the most advanced stage identified across the three assessment methods.

Variables

The dependent variable was severe LS, defined as LS-3, with non-severe LS (LS-1 and LS-2 combined) as the reference category. Independent variables comprised sociodemographic factors (age group, gender, religion, marital status, and educational status); behavioural factors (history of falls, history of smoking, and history of alcohol use); BMI category; and cardiometabolic disorders (central obesity based on waist–hip ratio [WHR], hypertension, diabetes mellitus, and hyperlipidaemia). An aggregate cardiometabolic burden score was additionally constructed by summing the number of cardiometabolic disorders (central obesity, hypertension, diabetes mellitus, hyperlipidaemia), categorised as 0, 1, 2, or ≥ 3 .

Statistical analysis

Data were entered in Microsoft Excel 2016 and analysed using Stata version 17 (StataCorp, College Station, TX, USA). Categorical variables are reported as frequencies and percentages; continuous variables are expressed as

median and interquartile range (IQR), as normality was rejected using the Shapiro–Wilk test and visual inspection of histograms. All contingency tables satisfied the assumptions of Pearson's chi-square test, with no expected cell count less than 5. Therefore, Pearson's chi-square test was used to assess associations between categorical variables and LS severity. The Mann–Whitney U test was used for continuous variables.

All tests were two-sided; a p-value <0.05 was considered statistically significant. Variables with $p < 0.1$ in univariate analysis were entered into a multivariable logistic regression model to identify independent correlates of severe LS and control for potential confounders. Multicollinearity among independent variables was assessed using variance inflation factors (VIF). Results are presented as adjusted odds ratios (aOR) with 95% confidence intervals (CIs). Given the high prevalence of severe LS, ORs may overestimate the true relative risk; this should be considered when interpreting the magnitude of associations.

An exploratory dose–response analysis was pre-specified in the statistical analysis plan to assess the relationship between cumulative cardiometabolic disorder burden and severe LS. Trend across ordered categories was assessed using the score test for trend. Model goodness-of-fit was evaluated using the Hosmer–Lemeshow test, and overall discriminatory ability was assessed using receiver operating characteristic (ROC) curve analysis, which quantifies the model's ability to distinguish between severe and non-severe LS across all possible classification thresholds.²⁷

Ethical considerations and reporting standards

The study protocol was approved by the Institutional Ethics Committee of Grant Government Medical College and Sir J. J. Group of Hospitals, Mumbai, prior to commencement of the study (Reference No.: IEC/Pharm/RP/315/2025; IEC Registration No.: ECR/382/Inst/MH/2023/RR-24). Written informed consent was obtained from all participants after explaining the study objectives, procedures, and voluntary nature of participation. Confidentiality and anonymity of participant information were strictly maintained throughout the study, and the collected data were used solely for research purposes.

RESULTS

A total of 264 participants aged ≥ 60 years were included in the study. The median age of the participants was 70 years (IQR: 66–74 years). Baseline sociodemographic, behavioural, and cardiometabolic characteristics of the study participants are presented in Table 1. Participants aged ≥ 70 years constituted 52.3% of the study population, while females accounted for 57.6%. The majority of participants were Hindus (59.5%), married (61.7%), and non-graduates (91.7%). A history of falls was reported by

53.8% of participants, whereas 17.8% and 7.9% reported a history of smoking and alcohol use, respectively. Overall, 66.3% of participants had a body mass index ≥ 23 kg/m². Regarding cardiometabolic characteristics, 68.2% had central obesity based on waist–hip ratio criteria,

while hypertension, diabetes mellitus, and hyperlipidaemia were present in 67.8%, 53.8%, and 23.1% of participants, respectively. Nearly half (49.6%) had three or more concurrent cardiometabolic disorders.

Table 1: Sociodemographic, behavioural and cardiometabolic characteristics of study participants (n=264).

Variables	Category	Frequency (N)	Percentage (%)
Gender	Male	112	42.4
	Female	152	57.6
Age group (year)	60–69	126	47.7
	≥ 70	138	52.3
Religion	Hindu	157	59.5
	Muslim	80	30.3
	Christian	27	10.2
Marital status	Married	163	61.7
	Widowed	101	38.3
Educational status	Graduate	22	8.3
	Non-graduate	242	91.7
History of fall	Absent	122	46.2
	Present	142	53.8
History of alcohol use	Absent	243	92.1
	Present	21	7.9
History of smoking	Absent	217	82.2
	Present	47	17.8
Body mass index (kg/m²)	<23	89	33.7
	≥ 23	175	66.3
Central obesity (based on waist–hip ratio)	Absent	84	31.8
	Present	180	68.2
Hypertension	Absent	85	32.2
	Present	179	67.8
Diabetes mellitus	Absent	122	46.2
	Present	142	53.8
Hyperlipidaemia	Absent	203	76.9
	Present	61	23.1
Number of cardiometabolic disorders	0	37	14.0
	1	44	16.7
	2	52	19.7
	≥ 3	131	49.6

Table 2: Stage-wise and severity-wise classification of locomotive syndrome among study participants (n=264).

Locomotive syndrome classification	Locomotive syndrome category	Frequency (N)	Percentage (%)
Stage-wise classification	Non-LS	0	0.0
	Mild LS (LS-1)	56	21.2
	Moderate LS (LS-2)	62	23.5
	Severe LS (LS-3)	146	55.3
Severity-wise classification	Non-severe LS (LS-1 + LS-2)	118	44.7
	Severe LS (LS-3)	146	55.3

LS: locomotive syndrome.

Table 2 presents the stage-wise and severity-wise distribution of locomotive syndrome based on the combined assessment using the Stand-Up Test, Two-Step

Test and GLFS-25. All 264 participants were classified as having LS; none met criteria for non-LS. LS-3 was observed in 55.3% of participants, while 21.2% and

23.5% were classified as LS-1 and LS-2, respectively. For further analysis, LS-1 and LS-2 were grouped as non-severe LS (44.7%) and LS-3 was considered severe LS.

Participants with severe LS had significantly higher median age [73 years (IQR: 70–75) vs 67 years (IQR: 63–68), $p<0.001$] and higher median BMI [25.19 kg/m² (IQR: 23.07–25.86) vs 22.75 kg/m² (IQR: 20.83–25.24), $p<0.001$] compared to those with non-severe LS (Mann–

Whitney U test). Table 3 presents the association of sociodemographic, behavioural and cardiometabolic factors with LS severity. Severe LS was significantly associated with female gender, age ≥ 70 years, widowed status, non-graduate educational status, history of falls, smoking, BMI ≥ 23 kg/m², central obesity, hypertension, diabetes mellitus and hyperlipidaemia (all $p<0.05$). Religion and history of alcohol use were not significantly associated with LS severity.

Table 3: Association of sociodemographic, behavioural and cardiometabolic factors with severity of locomotive syndrome (n=264).

Independent variables	Category	Non-severe LS (n=118) N (%)	Severe LS (n=146) N (%)	χ^2 (df)	P value
Gender	Male	61 (54.5)	51 (45.5)	7.51 (1)	0.006
	Female	57 (37.5)	95 (62.5)		
Age group (year)	60–69	92 (73.0)	34 (27.0)	78.20 (1)	<0.001
	≥ 70	26 (18.8)	112 (81.2)		
Religion	Hindu	70 (44.6)	87 (55.4)	0.25 (2)	0.883
	Muslim	37 (46.3)	43 (53.8)		
	Christian	11 (40.7)	16 (59.3)		
Marital status	Married	85 (52.1)	78 (47.9)	9.57 (1)	0.002
	Widowed	33 (32.7)	68 (67.3)		
Educational status	Graduate	15 (68.2)	7 (31.8)	5.36 (1)	0.021
	Non-graduate	103 (42.6)	139 (57.4)		
History of fall	Absent	65 (53.3)	57 (46.7)	6.76 (1)	0.009
	Present	53 (37.3)	89 (62.7)		
History of alcohol use	Absent	106 (43.6)	137 (56.4)	1.43 (1)	0.232
	Present	12 (57.1)	9 (42.9)		
History of smoking	Absent	104 (47.9)	113 (52.1)	5.14 (1)	0.023
	Present	14 (29.8)	33 (70.2)		
Body mass index (kg/m²)	<23	60 (67.4)	29 (32.6)	28.05 (1)	<0.001
	≥ 23	58 (33.1)	117 (66.9)		
Central obesity (based on waist–hip ratio)	Absent	58 (69.0)	26 (31.0)	29.55 (1)	<0.001
	Present	60 (33.3)	120 (66.7)		
Hypertension	Absent	57 (67.1)	28 (32.9)	25.36 (1)	<0.001
	Present	61 (34.1)	118 (65.9)		
Diabetes mellitus	Absent	72 (59.0)	50 (41.0)	18.81 (1)	<0.001
	Present	46 (32.4)	96 (67.6)		
Hyperlipidaemia	Absent	101 (49.8)	102 (50.2)	9.09 (1)	0.003
	Present	17 (27.9)	44 (72.1)		
Number of cardiometabolic disorders	0	28 (75.7)	9 (24.3)	52.91 (3)	<0.001
	1	30 (68.2)	14 (31.8)		
	2	30 (57.7)	22 (42.3)		
	≥ 3	30 (22.9)	101 (77.1)		

LS, locomotive syndrome. Data are expressed as N (%), where percentages are row-wise percentages. P values were calculated using Pearson's Chi-square test

Prior to interpreting the logistic regression model, collinearity diagnostics were examined. All correlates yielded VIF values ranging from 1.03 (Marital Status) to 2.31 (Central Obesity/WHR), well below the accepted threshold of 5, and Tolerance values ranged from 0.434 to 0.969. These findings confirm the absence of multicollinearity, supporting the reliability of the regression coefficients. On multivariable logistic regression analysis (Table 4, Figure 1), age ≥ 70 years

emerged as the strongest independent correlate of severe locomotive syndrome. Female gender, non-graduate educational status, history of falls and smoking were also independently associated with severe LS. Among cardiometabolic factors, central obesity and hyperlipidaemia remained significant in the adjusted model. In contrast, marital status, body mass index category, hypertension and diabetes mellitus were not independently significant in the adjusted model.

Table 4: Multivariable logistic regression analysis of factors associated with severe locomotive syndrome (n=264).

Independent variable	Category	Crude OR (95% CI)	Adjusted OR (95% CI)	P value
Gender	Male	1 (Reference)	1 (Reference)	0.012
	Female	1.99 (1.18–3.38)	2.60 (1.23–5.47)	
Age group (year)	60–69	1 (Reference)	1 (Reference)	<0.001
	≥70	11.66 (6.28–21.76)	15.77 (7.41–33.58)	
Religion*	Hindu	1 (Reference)	—	—
	Muslim	0.94 (0.55–1.61)	—	
	Christian	1.17 (0.51–2.68)	—	
Marital status	Married	1 (Reference)	1 (Reference)	0.094
	Widowed	2.25 (1.30–3.90)	1.85 (0.90–3.82)	
Educational status	Graduate	1 (Reference)	1 (Reference)	0.008
	Non-graduate	2.89 (1.06–8.67)	6.79 (1.66–27.83)	
History of fall	Absent	1 (Reference)	1 (Reference)	0.004
	Present	1.91 (1.14–3.23)	2.89 (1.40–5.95)	
History of alcohol use*	Absent	1 (Reference)	—	—
	Present	0.58 (0.21–1.57)	—	
History of smoking	Absent	1 (Reference)	1 (Reference)	0.009
	Present	2.17 (1.06–4.63)	3.95 (1.42–11.03)	
Body mass index (kg/m²)	<23	1 (Reference)	1 (Reference)	0.133
	≥23	4.17 (2.43–7.19)	0.27 (0.05–1.49)	
Central obesity (based on waist–hip ratio)	Absent	1 (Reference)	1 (Reference)	0.021
	Present	4.46 (2.47–8.12)	6.22 (1.32–29.29)	
Hypertension	Absent	1 (Reference)	1 (Reference)	0.204
	Present	3.94 (2.20–7.09)	1.70 (0.75–3.86)	
Diabetes mellitus	Absent	1 (Reference)	1 (Reference)	0.509
	Present	3.01 (1.76–5.13)	1.32 (0.58–2.98)	
Hyperlipidaemia	Absent	1 (Reference)	1 (Reference)	0.007
	Present	2.56 (1.33–5.10)	3.12 (1.37–7.12)	

LS, locomotive syndrome; OR, odds ratio; CI, confidence interval; * Religion and history of alcohol use were not included in the multivariable logistic regression model as their P values were >0.1 in the univariate analysis.

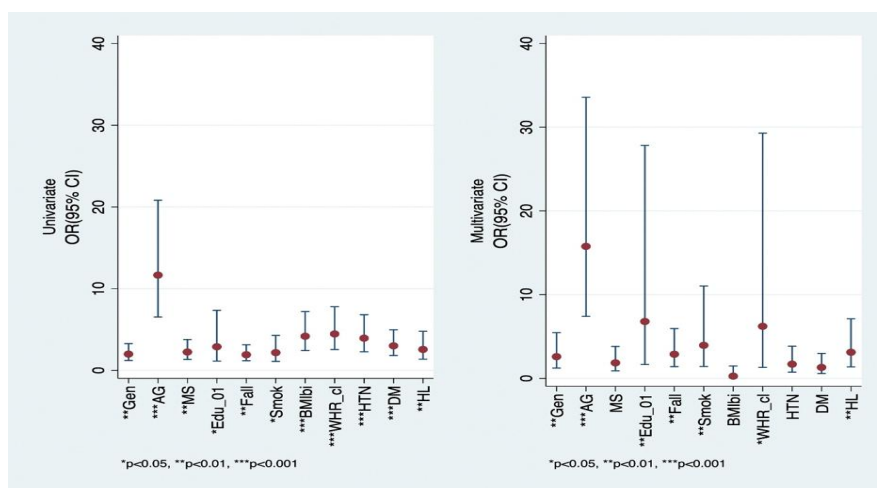


Figure 1: Forest plot showing univariate and multivariate odds ratios for factors associated with severe locomotive syndrome.

Gen, gender; AG, age group; MS, marital status; Edu_01, educational status; Fall, history of falls; Smok, history of smoking; BMibi, body mass index classification; WHR_cl, waist–hip ratio–based central obesity classification; HTN, hypertension; DM, diabetes mellitus; HL, hyperlipidemia.

The dose–response analysis (Table 5) demonstrated that the crude odds of severe locomotive syndrome increased progressively with the number of cardiometabolic disorders. Compared with individuals without any cardiometabolic disorder, those with three or more disorders had markedly higher odds of severe locomotive syndrome, whereas those with one or two disorders did not show statistically significant increases individually. The overall test of homogeneity ($\chi^2 = 52.71$, $p < 0.001$)

and the score test for trend ($\chi^2 = 47.77$, $p < 0.001$) confirmed a significant monotonic dose–response relationship, indicating that the likelihood of severe locomotive syndrome increased with an increasing burden of cardiometabolic disorders. Adjusted odds ratios were not estimated for this composite variable because its constituent conditions (hypertension, diabetes mellitus, hyperlipidaemia, and central obesity) were already included separately in the multivariable logistic regression model.

Table 5: Dose-response relationship between cardiometabolic disorder burden and severe locomotive syndrome (n=264).

Number of cardiometabolic disorders	Crude Odds ratio (95% CI)	χ^2 value	P value
0	Reference	—	—
1	1.45 (0.54–3.92)	0.55	0.459
2	2.28 (0.88–5.92)	3.05	0.081
≥3	10.47 (3.99–27.50)	35.34	<0.001
Overall test of homogeneity		52.71	<0.001
Score test for trend		47.77	<0.001

Model performance

The multivariable logistic regression model was statistically significant (likelihood ratio $\chi^2 = 143.13$, $p < 0.001$) and explained 39.43% of the variability in severe

locomotive syndrome (McFadden’s $R^2 = 0.3943$). The model demonstrated adequate goodness-of-fit according to the Hosmer–Lemeshow test ($\chi^2 = 10.404$, $p = 0.238$) and good discriminatory ability, with an area under the receiver operating characteristic (ROC) curve of 0.89 (Figure 2).

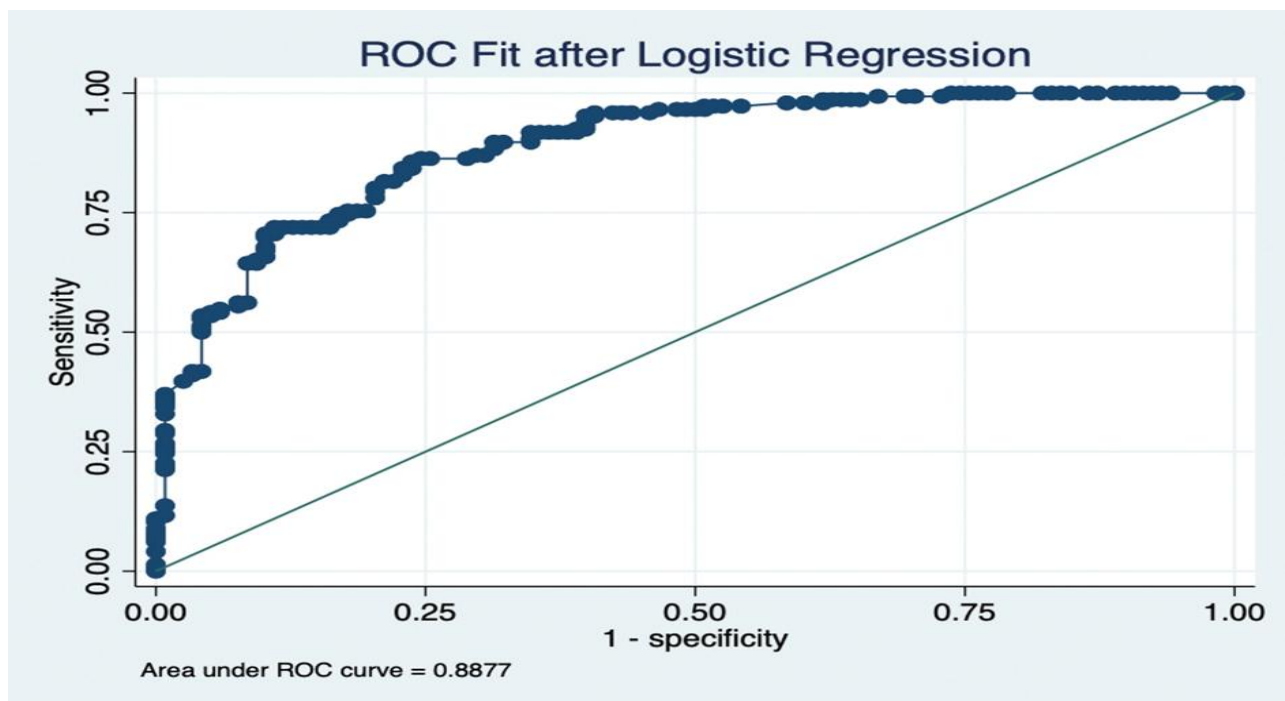


Figure 2: Receiver operating characteristic (ROC) curve for the logistic regression model predicting severe locomotive syndrome.

ROC - Receiver operating characteristic

DISCUSSION

This facility-based cross-sectional study among 264 older adults attending an urban health training centre in Maharashtra found a high burden of severe locomotive syndrome (LS-3), affecting 55.3% of participants. Advancing age, female gender, non-graduate educational status, history of falls, smoking, central obesity and hyperlipidaemia were independently associated with severe LS. A significant dose-response relationship was observed between cumulative cardiometabolic burden and severe LS severity.

The present study found a high burden of severe LS, affecting 55.3% of participants. This prevalence is higher than that reported in community-based studies, particularly from Japanese populations, likely reflecting the healthcare-seeking nature of the study cohort, which may include more individuals with comorbidities and functional limitations.^{9–12}

Advancing age emerged as the strongest independent correlate of severe LS, with individuals aged ≥ 70 years having 15.77 times higher odds, consistent with previous studies evidence linking ageing to musculoskeletal decline, sarcopenia and reduced physical performance.^{4,5,28} Female gender was independently associated with severe LS, with 2.60 times higher odds compared to males. Previous studies have reported a higher prevalence and severity of LS among women. This may be related to differences in body composition, lower muscle mass and hormonal influences affecting musculoskeletal health.^{15,16,28}

Non-graduate educational status was associated with 6.79 times higher odds of severe LS. Although direct evidence linking education and LS is limited, previous research suggests an association between lower educational level and mobility limitation among older adults.^{29,30}

A history of falls was independently associated with severe LS, with 2.89 times higher odds. This may be explained by the bidirectional relationship between LS and falls, where impaired balance and muscle weakness increase fall risk, while falls further exacerbate functional decline.^{25,28,31} Smoking was significantly associated with severe LS, with 3.95 times higher odds. This association may be attributed to the adverse effects of smoking on muscle mass, bone health and vascular function, which collectively contribute to functional decline. Previous studies have identified smoking as an important correlate of locomotive syndrome.^{6,15}

Body mass index (BMI) ≥ 23 kg/m² did not show a significant association with severe LS after adjustment for confounding factors. This finding contrasts with that of Nakamura et al where a BMI cut-off of ≥ 23.5 kg/m² remained significant in multivariable regression for LS.¹⁶

Central obesity remained an independent correlate of severe LS, with individuals exhibiting 6.22 times higher odds. Previous studies have reported that central obesity, assessed using waist circumference, is associated with LS. The present study extends these findings by demonstrating that waist-hip ratio is a stronger correlate, suggesting fat distribution may be more relevant than overall adiposity.^{32,33} Hyperlipidaemia was independently associated with severe LS, with 3.12 times higher odds. Although hypertension and diabetes mellitus were significant in bivariate analysis, these associations were not retained after adjustment. This contrasts with previous studies where only hypertension was significant in bivariate analysis.¹⁶ A dose-response relationship was observed with an increasing number of cardiometabolic disorders, indicating a cumulative effect on LS severity. Evidence from previous studies suggests that cardiometabolic disorders and their coexistence are significantly associated with locomotive syndrome among older adults.^{13,34–38}

From a public health perspective, these observations underscore the need for integrated, community-based approaches that address both locomotive function and cardiometabolic health. Early identification of high-risk individuals, along with comprehensive interventions including promotion of regular physical activity, structured exercise programmes, balanced nutrition, smoking cessation, appropriate pharmacological management, treatment of comorbid conditions, use of assistive devices and lifestyle modifications such as weight management and fall prevention may help reduce the burden of severe LS, delay disease progression and promote healthy ageing.^{8,21,28,39,40}

Strengths and limitations

Strengths of this study include the use of three validated objective assessment tools for LS classification, the assessment of cardiometabolic multimorbidity burden using a dose-response approach, the pre-specified statistical analysis plan, assessment of multicollinearity and the application of a well-calibrated multivariable model. The study provides the novel evidence from Maharashtra on severe LS correlates in an urban primary care context.

Several limitations must be acknowledged. The facility-based convenience sampling approach limits generalisability to the broader urban elderly population; individuals attending the UHTC may have greater comorbidity and functional limitation than community-dwelling peers. The cross-sectional design precludes any inference of temporality or causality. Self-reported comorbidities are subject to recall bias, despite cross-verification with medical records. The absence of sarcopenia and frailty assessment as potential confounders is a limitation. Odds ratios in this study may overestimate the relative risk of associations given the high prevalence of the outcome (55.3%). Additionally,

the study was conducted at a single centre over a one-month period, which may limit the generalizability and representativeness of the findings. Future community-based studies are needed to validate these findings.

CONCLUSION

Severe locomotive syndrome was prevalent in more than half of older adults attending an urban health training centre in Maharashtra, with advancing age, female gender, lower educational status, history of falls, smoking, central obesity and hyperlipidaemia emerging as significant independent correlates. The strong dose-response relationship between cardiometabolic multimorbidity burden and severe LS highlights the cumulative impact of comorbidity on locomotive function. These findings support the integration of LS screening into existing NCD management platforms in urban primary care settings, with targeted multicomponent interventions for high-risk older adults, as a strategy to reduce functional dependency and promote healthy ageing. Prospective community-based studies and clinical trials of integrated screening interventions are warranted.

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REFERENCES

- World Health Organization. Ageing and health. Geneva: World Health Organization; 2025. Available from: <https://www.who.int/news-room/fact-sheets/detail/ageing-and-health>
- Perianayagam A, Bloom D, Lee J, Parasuraman S, Sekher TV, Mohanty SK, et al. Cohort Profile: The Longitudinal Ageing Study in India (LASI). *Int J Epidemiol*. 2022;51(4):e167-76.
- United Nations. World Population Prospects 2019: Data Booklet [Internet]. New York: United Nations; 2019. Available at: <https://www.un-ilibrary.org/content/books/9789210042475>. Accessed on 17 May 2026.
- Beard JR, Officer A, de Carvalho IA, Sadana R, Pot AM, Michel JP, et al. The World report on ageing and health: a policy framework for healthy ageing. *Lancet*. 2016;387(10033):2145-2154.
- Iwamoto Y, Imura T, Hirata K, Ikuta Y, Ushio K, Mikami Y, et al. The risk factors for development or progression of locomotive syndrome: a systematic review. *Nagoya J Med Sci*. 2025;87(1):60-75.
- Nakamura K. A “super-aged” society and the “locomotive syndrome”. *J Orthop Sci*. 2008;13(1):1-2.
- Nakamura K. The concept and treatment of locomotive syndrome: its acceptance and spread in Japan. *J Orthop Sci*. 2011;16(5):489-491.
- Nakamura K, Ogata T. Locomotive syndrome: definition and management. *Clin Rev Bone Miner Metab*. 2016;14(2):56-67.
- Taniguchi M, Ikezoe T, Tsuboyama T, Tabara Y, Matsuda F, Ichihashi N. Prevalence and physical characteristics of locomotive syndrome stages as classified by the new criteria 2020 in older Japanese people: results from the Nagahama study. *BMC Geriatr*. 2021;21(1):489.
- Shanmuganathan K, Kalpana S, Sundar JS, Valarmathi S, Srinivas G. An exploration of locomotor syndrome among geriatric population: a narrative review. *Neurol Neuropsychiatr Psychosom*. 2024;16(5):87-90.
- Nagilla J, Nagarajan S, Trovagunta LG, Gakkula H, Anup KP, Rampalli VC. Teeth loss and its association with locomotive syndrome among patients visiting the outpatient department of a dental school in Mahbubnagar, India-a cross sectional study. *Acta Biomed*. 2021;92(2):e2021040.
- Barik M, Panda SN. Cardiometabolic multimorbidity (CMM) among older adults in India. *BMC Cardiovasc Disord*. 2025;25(1):750.
- Pai M, Muhammad T, Ahmed W. Life course rural-urban residence and multimorbidity among older adults in India. *Arch Gerontol Geriatr Plus*. 2025;2(4):100211.
- Kobayashi T, Morimoto T, Shimanoe C, Ono R, Otani K, Mawatari M. Risk factors for progression of the severity of locomotive syndrome: a two-year longitudinal observational study. *J Orthop Sci*. 2024;29(2):646-652.
- Akahane M, Yoshihara S, Maeyashiki A, Tanaka Y, Imamura T. Lifestyle factors are significantly associated with the locomotive syndrome: a cross-sectional study. *BMC Geriatr*. 2017;17:241.
- Nakamura M, Kobashi Y, Hashizume H, Oka H, Kono R, Nomura S, et al. Locomotive syndrome is associated with body composition and cardiometabolic disorders in elderly Japanese women. *BMC Geriatr*. 2016;16(1):166.
- Vasudevan DA, Klawans MR, Northrup TF, Stotts AL. Diagnosis and management of obesity among South Asians: a paradigm. *J Fam Med Community Health*. 2015;2(7):1056.
- Sruthi KG, John SM, Marconi DS. Assessment of obesity in the Indian setting: a clinical review. *Clin Epidemiol Glob Health*. 2023;23:101348.
- Ogata T, Muranaga S, Ishibashi H, Ohe T, Izumida R, Yoshimura N, et al. Development of a screening program to assess motor function in the adult

- population: a cross-sectional observational study. *J Orthop Sci*. 2015;20(5):888-95.
20. Seichi A, Hoshino Y, Doi T, Akai M, Tobimatsu Y, Iwaya T. Development of a screening tool for risk of locomotive syndrome in the elderly: the 25-question Geriatric Locomotive Function Scale. *J Orthop Sci*. 2012;17(2):163-72.
21. Ishibashi H. Locomotive syndrome in Japan. *Osteoporos Sarcopenia*. 2018;4(3):86-94.
22. Yoshimura N, Muraki S, Oka H, Tanaka S, Ogata T, Kawaguchi H, et al. Association between new indices in the locomotive syndrome risk test and decline in mobility: third survey of the ROAD study. *J Orthop Sci*. 2015;20(5):896-905.
23. Yamada K, Muranaga S, Shinozaki T, Nakamura K, Tanaka S, Ogata T, et al. Age independency of mobility decrease assessed using the Locomotive Syndrome Risk Test in elderly with disability: a cross-sectional study. *BMC Geriatr*. 2018;18:28.
24. Locomotive Challenge Council. Locomotive syndrome pamphlet 2020 [Internet]. Tokyo: Japanese Orthopaedic Association; 2020 [cited 2026 June 08]. Available at: <https://locomo-joa.jp/>. Accessed on 17 May 2026.
25. Yamada K, Ito YM, Akagi M, Chosa E, Fuji T, Hirano K, et al. Reference values for the locomotive syndrome risk test quantifying mobility of 8681 adults aged 20-89 years: a cross-sectional nationwide study in Japan. *J Orthop Sci*. 2020;25(6):1084-92.
26. Ogata T, Yamada K, Miura H, Hino K, Kutsuna T, Watamori K, et al. Feasibility and applicability of locomotive syndrome risk test in elderly patients who underwent total knee arthroplasty. *Mod Rheumatol*. 2023;33(6):1197-203.
27. Nahm FS. Receiver operating characteristic curve: overview and practical use for clinicians. *Korean J Anesthesiol*. 2022;75(1):25-36.
28. Matsumoto H, Hagino H, Wada T, Kobayashi E. Locomotive syndrome presents a risk for falls and fractures in the elderly Japanese population. *Osteoporos Sarcopenia*. 2016;2(3):156-163.
29. Lee YY, Chen CL, Lee IC, Lee IC, Chen NC. History of falls, dementia, lower education levels, mobility limitations, and aging are risk factors for falls among the community-dwelling elderly: a cohort study. *Int J Environ Res Public Health*. 2021;18(17):9356.
30. Sainio P, Martelin T, Koskinen S, Heliövaara M. Educational differences in mobility: the contribution of physical workload, obesity, smoking and chronic conditions. *J Epidemiol Community Health*. 2007;61(5):401-8.
31. Nishimoto J, Hamada K, Deguchi N, Tanaka R. Association between locomotive syndrome and pre-frailty in community-dwelling older adults: a cross-sectional study. *Arch Gerontol Geriatr Plus*. 2026;3(1):100230.
32. Tanaka S, Ando K, Kobayashi K, Seki T, Ishizuka S, Machino M, et al. Waist circumference measured by bioelectrical impedance analysis is interchangeable with manual measurement: increased waist circumference is associated with locomotive syndrome risk. *Biomed Res Int*. 2019;2019:5971030.
33. Muramoto A, Imagama S, Ito Z, Hirano K, Tauchi R, Ishiguro N, et al. Waist circumference is associated with locomotive syndrome in elderly females. *J Orthop Sci*. 2014;19(4):612-9.
34. Goto C, Maruya K, Morita Y, Arai T, Yamaguchi S, Yamada K, et al. Prevalence and coexistence of locomotive syndrome with reduced mobility and metabolic syndrome: a cross-sectional study of 35,059 Japanese adults. *Sci Rep*. 2025;15(1):13547.
35. Mitani G, Nakamura Y, Miura T, Harada Y, Sato M, Watanabe M. Evaluation of the association between locomotive syndrome and metabolic syndrome. *J Orthop Sci*. 2018;23(6):1056-1062.
36. Ninomiya K, Takahira N, Ikeda T, Suzuki K, Sato R, Hirakawa K. Prevalence of locomotive syndrome in Japanese patients more than 10 years after total hip arthroplasty: a cross-sectional cohort study. *J Orthop Sci*. 2022;27(1):176-80.
37. Morita Y, Ito H, Kawaguchi S, Nishitani K, Nakamura S, Kuriyama S, et al. Systemic chronic diseases coexist with and affect locomotive syndrome: the Nagahama Study. *Mod Rheumatol*. 2023;33(3):608-16.
38. Yoshimoto T, Shinozaki T, Matsudaira K. Bidirectional association between locomotive syndrome and metabolic syndrome: a 6-year longitudinal study in Japanese workers. *Prev Med*. 2025;198:108334.
39. Ishibashi Y, Nishida M, Hirai M, Uezono S, Kitakaze S, Kota M, et al. Association between locomotive syndrome and physical activity in long-term inpatients of psychiatric care wards in Japan: a preliminary study. *Healthcare (Basel)*. 2022;10(9):1741.
40. Nayasista AH, Tinduh D, Alit Pawana IP, Mei Wulan SM, Utomo DN, Soenarnatalina M. Effect of combined locomotor training and aerobic exercise on increasing handgrip strength in elderly with locomotive syndrome: a randomised controlled trial. *Ann Med Surg (Lond)*. 2022;78:103800.

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