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# New indicators related to the osteosarcopenia in the elderly: assessment of intrinsic capacity

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## Abstract

**Background** While intrinsic capacity (IC) has been associated with reduced sarcopenia risk, its relationship with osteosarcopenia remains unexplored. This study aimed to elucidate the association between IC and osteosarcopenia in older adults.

**Methods** This cross-sectional study enrolled outpatient patients  $\geq 60$  years to investigate IC-osteosarcopenia associations. IC was quantified through a multidimensional score integrating cognition, mobility, vitality, psychological, and sensory domains. Osteosarcopenia was defined as concurrent osteoporosis and sarcopenia. Participants underwent stratification based on osteoporosis/sarcopenia comorbidity status. Multivariable-adjusted logistic models assessed IC-osteosarcopenia risk gradients, with subgroup analyses exploring age/sex-specific effects and comorbidity interactions.

**Results** In this cohort of 461 older adults (median age 80 years), osteosarcopenia prevalence reached 26%. Logistic regression analysis identified: cognitive [odds ratio (OR): 0.871, 95% confidence interval (CI): 0.808–0.933] and sensory (OR: 0.633, 95% CI: 0.417–0.950) impairments specifically predicted osteosarcopenia, while vitality deficits demonstrated dual risks for both sarcopenia (OR: 0.820, 95% CI: 0.725–0.920) and osteosarcopenia (OR: 0.736, 95% CI: 0.648–0.826). Locomotor impairment and psychological distress emerged as pan-risk factors across sarcopenia, osteoporosis, and osteosarcopenia. Total IC scores exhibited dose-dependent associations with all three musculoskeletal outcomes ( $P < 0.05$ ), maintaining significance across age/sex subgroups and after confounding variables adjustment.

**Conclusion** Total IC score serves as a significant predictor of osteosarcopenia in elderly patients. Cognition, mobility, vitality, psychological, and sensory domains were associated with osteosarcopenia.

**Keywords** Aged, Osteosarcopenia, Osteoporosis, Sarcopenia, Intrinsic capacity

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## Introduction

Osteosarcopenia, a term first introduced by Duque, specifically characterizes a distinct subset of older individuals concurrently affected by both osteoporosis and sarcopenia, highlighting its status as a unique clinical syndrome [1]. A study has revealed that the prevalence of osteosarcopenia increases with age among older adults, with the prevalence in men rising from 14.3% at ages 60–64 to 59.4% at ages 75 and above, and in women from 20.3% at ages 60–64 to 48.3% at ages 75 and above [2]. Osteoporosis and sarcopenia, two interrelated pathological conditions, exhibit overlapping risk factors that collectively contribute to frailty progression [3]. Their synergistic effects significantly elevate risks of accidental falls, fragility fractures, and subsequent hospital admissions, ultimately leading to increased mortality rates and substantial financial burdens on healthcare systems [4, 5]. Patients with osteosarcopenia demonstrate significantly elevated risks compared to those without the condition, with hazard ratios of 1.60 (95% CI 1.07–2.38) for falls and 1.54 (95% CI 1.13–2.08) for fractures [6]. The condition is associated with a 2.6-fold higher mortality rate (15.9% vs. 6.1%) compared to non-affected individuals [6].

First introduced by the World Health Organization in 2017, the intrinsic capacity (IC) framework—defined as the combination of an individual's physical and mental capacities—operationalizes healthy aging through five measurable domains: cognition, vitality (nutrition), mobility, psychological state (depression), and sense [7, 8]. These core components have been validated as predictive indicators of social engagement patterns in older populations, shifting the focus from disease to functional ability in aging. A study in 2023 indicated that the more severe the IC impairment, the higher the risk of developing sarcopenia, suggesting that IC can be utilized for the detection and treatment of sarcopenia [9]. A study indicated that IC impairment, particularly locomotor impairment, may be associated with osteoporosis in older adults [10]. Despite the growing recognition of the importance of IC in aging, no studies have yet explored its relationship with osteosarcopenia. Consequently, the present study aims to examine the association between IC and osteosarcopenia in the older population.

## Methods

### Study design and population

This was a cross-sectional study. For this study, we examined IC among elderly patients  $\geq 60$  years at Beijing Hospital in China from November 2020 to December 2023. Initially, 745 participants were recruited. However, 284 participants were excluded based on the following criteria: (1) being under 60 years of age; (2) having incomplete intrinsic capacity data; and (3) lacking osteosarcopenia data. The final analysis included a total of 461

participants (Fig. 1). This study was conducted with the approval of the Medical Ethics Committee of Beijing Hospital (Approval Number: 2024BJYYEC-KY083-02) and was performed in accordance with the Declaration of Helsinki. Given the retrospective nature of this study and the maintenance of patient anonymity, a waiver for informed consent was granted.

### Assessment of osteosarcopenia

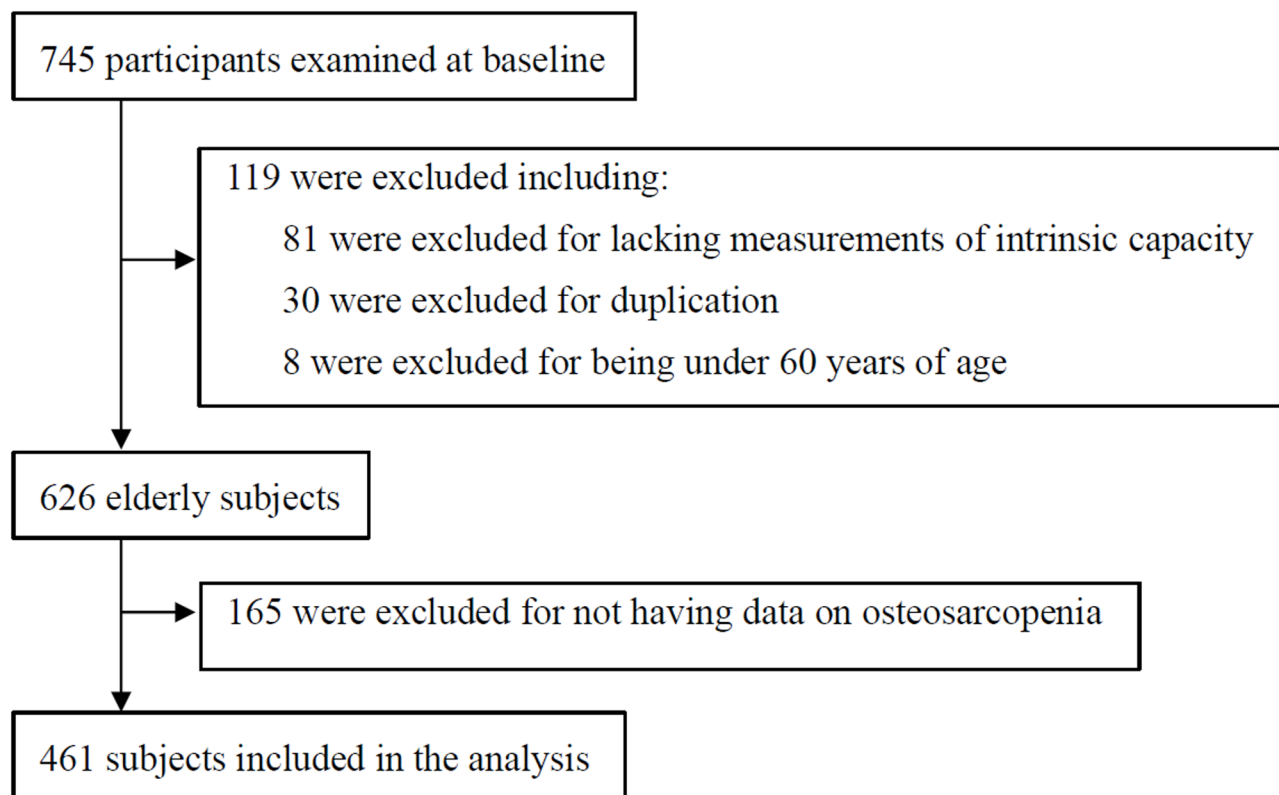
Sarcopenia was defined as the presence of both low appendicular skeletal muscle mass index ( $< 7.0$  kg/m<sup>2</sup> for men and  $< 5.7$  kg/m<sup>2</sup> for women) and low handgrip strength ( $< 28$  kg for men and  $< 18$  kg for women), and/or slow gait speed ( $< 1.0$  m/s) [11]. These criteria were recommended by the Asian Working Group for Sarcopenia in 2019. Additionally, individuals with a self-reported history of sarcopenia were also included. Skeletal muscle mass was evaluated using bioelectrical impedance analysis with the Inbody S10 device (Korea). Grip strength was measured using the Leaping Health™ WL-1000 dynamometer, with two trials conducted for each hand to determine the maximum grip strength. Gait speed was assessed by timing participants as they walked 6 m at their usual pace.

Osteosarcopenia was defined as the coexistence of osteoporosis and sarcopenia. Bone mineral density of the lumbar spine and bilateral femoral neck was measured using Dual-Energy X-ray Absorptiometry (GE Healthcare, Lunar iDXA). Osteoporosis was diagnosed based on a T-score below  $-2.5$ , in accordance with World Health Organization criteria [12] or through self-reported history of osteoporosis.

Participants were categorized into four groups according to their osteoporosis and sarcopenia status. The normal group included individuals without either osteoporosis or sarcopenia. The sarcopenia group consisted of those with sarcopenia but without osteoporosis. The osteoporosis group included participants with osteoporosis but not sarcopenia. Finally, the osteosarcopenia group comprised individuals with both sarcopenia and osteoporosis.

### Measurements of intrinsic capacity

IC framework was originally proposed by the World Health Organization [7]. Two experienced and rigorously trained nurses administered the IC assessment to all participants using a face-to-face questionnaire. The IC score was calculated based on the following method: each domain is assigned a maximum of 2 points. The total IC score is then obtained by summing the scores across the five domains (maximum score = 10), with higher scores reflecting stronger intrinsic capacity in older adults [13]. We used the Mini-Mental State Examination (MMSE) to evaluate cognitive status, with scores  $\geq 27$  assigned



**Fig. 1** Flowchart of Participant Selection

2 points,  $\geq 10$  assigned 1 point, otherwise 0 points [14]. For evaluating vitality, the Mini Nutritional Assessment Short-Form (MNA-SF) was employed, with scores  $\geq 12$  indicating good nutritional health and earning 2 points,  $\geq 8$  assigned 1 points, otherwise 0 points [15]. Locomotion was assessed using the Short Physical Performance Battery (SPPB) [16]. Scores of  $\geq 10$  were awarded 2 points, while scores below 3 received 0 points, otherwise 1 point. Depressive symptoms were identified using the Geriatric Depression Scale-15 (GDS-15), with scores  $\leq 4$  indicating good psychological status and earning 2 points,  $\geq 9$  assigned 0 points, otherwise 1 point [17]. Sensory function was assessed based on auditory and visual impairments: 0 points for both impaired, 1 point for either vision or hearing impaired, and 2 points for both normal.

#### Data collection

Data were collected for the following variables: age, sex, education, body mass index (BMI), number of medications, Clinical Frailty Scale (CFS), blood pressure. Smoking status was assessed based on whether they currently smoke. Blood pressure was measured three times using a digital sphygmomanometer (Omron, Japan). Laboratory data were extracted from electronic medical records, including fasting plasma glucose (FPG), HbA1c, total cholesterol, high-density lipoprotein cholesterol

(HDL-C), low-density lipoprotein cholesterol (LDL-C), albumin, 25-OH-VD3, and creatinine.

#### Statistical analysis

The statistical presentation of variables was conducted as follows: Normally distributed continuous data were summarized as mean values with standard deviations, whereas non-normally distributed continuous measures were reported using median and interquartile range values. Categorical data were presented as frequency percentages. Analytical comparisons employed different approaches based on variable types - continuous variables were analyzed through one-way ANOVA while categorical differences were examined using Pearson's Chi-square tests. To address the issue of multiple comparisons, we employed the Bonferroni correction method. To investigate potential associations between IC domains and osteoporosis, sarcopenia, osteosarcopenia, multivariate logistic regression models were developed to assess relationships.

The analytical framework incorporated two hierarchical regression models to address potential confounding variables. The base model (model 1) maintained unadjusted estimates, with successive adjustments introduced in progressive specifications: Model 2 incorporated sex, education, smoking, and number of medications. Subpopulation analyses were conducted through

stratification by seven key characteristics: age tertiles, biological sex, smoking status, drinking status, body mass index (BMI) categories, stroke event history, and diabetic status. Between-strata heterogeneity was evaluated using Breslow-Day tests for interaction, with effect estimates expressed as adjusted odds ratios (ORs) with 95% confidence intervals. All statistical computations were executed using R statistical environment (version 4.4.2), with hypothesis testing conducted at  $\alpha=0.05$  threshold for statistical significance (two-tailed).

## Results

### Characteristics of participants

A total of 461 participants were included, with median age of 80 (73, 86) years and 225 (48.8%) women (Table 1). The normal group included 125 individuals (27.1%), the sarcopenia group had 67 (14.5%), the osteoporosis group comprised 149 (32.3%), and the osteosarcopenia group consisted of 120 (26.0%). Participants in the osteosarcopenia group were older than those in the normal group

(82 vs. 75 years). The osteosarcopenia group also had a higher proportion of females than the normal group (51.7% vs. 38.4%), although this was lower than the proportion in the osteoporosis group (51.7% vs. 57.1%). In terms of weight and BMI, individuals in the osteosarcopenia group were lower than those in both the normal and osteoporosis groups. They also exhibited reduced grip strength and gait speed compared to the normal group. Additionally, the osteosarcopenia group had a higher prevalence of hypertension, diabetes, and history of stroke, as evidenced by a greater number of medications compared to the normal group. Albumin levels were lower in the osteosarcopenia group, and they had a higher Clinical Frailty Scale (CFS-09) score compared to both the normal and osteoporosis groups.

The osteosarcopenia group exhibited the lowest scores in the total IC score, followed by the sarcopenia and osteoporosis groups (Table 2). Specifically, the osteosarcopenia group had the lowest scores in locomotion and cognition when compared to the other three groups.

**Table 1** Characteristics of groups stratified by sarcopenia and osteoporosis classification. Data are presented as mean  $\pm$  standard deviation, number (percentage), or median (interquartile range). Different lowercase letters mean significant differences between four groups. *BMI* Body mass index, *SBP* Systolic blood pressure, *DBP* Diastolic blood pressure, *FPG* Fasting plasma glucose, *HDL-c* High-density lipoprotein cholesterol, *LDL-c* Low density lipoprotein cholesterol, *CFS-09* Clinical frailty Scale-09

	Overall (n=461)	Normal (n=125)	Sarcopenia (n=67)	Osteoporosis (n=149)	Osteosarcopenia (n=120)	P-value
Female	225(48.8%)	48(38.4%) <sup>b</sup>	30(44.8%) <sup>ab</sup>	85(57.1%) <sup>a</sup>	62(51.7%) <sup>ab</sup>	0.016
Age (y)	80(73, 86)	75(70, 84) <sup>b</sup>	81(73, 85) <sup>ab</sup>	79(73, 84) <sup>b</sup>	82(77, 88) <sup>a</sup>	<0.001
High school or higher education	288(62.5%)	67(53.6%)	42(62.7%)	99(66.4%)	80(66.7%)	0.915
Weight (kg)	62.37 $\pm$ 12.81	67.41 $\pm$ 11.78 <sup>a</sup>	57.52 $\pm$ 13.39 <sup>b</sup>	65.47 $\pm$ 12.30 <sup>a</sup>	56.77 $\pm$ 10.90 <sup>b</sup>	<0.001
BMI (kg/m <sup>2</sup> )	23.11 $\pm$ 4.20	24.41 $\pm$ 3.61 <sup>a</sup>	21.34 $\pm$ 4.43 <sup>b</sup>	24.49 $\pm$ 4.03 <sup>a</sup>	21.21 $\pm$ 3.69 <sup>b</sup>	<0.001
Grip (kg)	20.00 $\pm$ 9.18	20.42 $\pm$ 9.53 <sup>b</sup>	18.02 $\pm$ 9.01 <sup>ac</sup>	20.61 $\pm$ 8.48 <sup>a</sup>	15.27 $\pm$ 6.81 <sup>c</sup>	<0.001
Gait speed (m/s)	0.67(0.24,0.95)	0.88(0.65, 1.11) <sup>a</sup>	0.61(0.26, 0.85) <sup>b</sup>	0.81(0.46, 1.03) <sup>ab</sup>	0.35(0.00, 0.63) <sup>c</sup>	<0.001
Current smoking	43(9.3%)	17(13.6%)	9(13.4%)	7(4.7%)	10(8.3%)	0.129
History of stroke	217(47.1%)	43(34.4%) <sup>c</sup>	24(35.8%) <sup>bc</sup>	75(50.3%) <sup>ab</sup>	75(62.5%) <sup>a</sup>	<0.001
Diabetes	241(52.2%)	49(39.2%) <sup>c</sup>	28(41.8%) <sup>bc</sup>	92(61.7%) <sup>a</sup>	72(60%) <sup>ab</sup>	<0.001
Hypertension	374(81.1%)	90(72.0%) <sup>b</sup>	47(70.1%) <sup>b</sup>	131(87.9%) <sup>a</sup>	106(88.3%) <sup>a</sup>	<0.001
Number of medications	7.00(4.00, 10.00)	5.00(3.00, 8.00) <sup>b</sup>	7.00(5.00, 9.75) <sup>a</sup>	7.00(5.00, 12.00) <sup>a</sup>	9.00(7.00, 11.75) <sup>a</sup>	<0.001
SBP (mmHg)	129.00(117.00,145.00)	129.00(116.00,142.00)	127.00(118.00,139.00)	127.00(115.00,145.00)	132.00(120.00,148.50)	0.269
DBP (mmHg)	72.00(65.00, 78.00)	73.00(67.00, 80.00)	73.00(62.50, 78.00)	72.00(66.00, 78.00)	70.00(64.00, 78.00)	0.448
FPG (mmol/L)	5.50(4.90, 6.70)	5.70(5.03, 6.78)	5.25(4.70, 6.60)	5.60(4.90, 6.80)	5.25(4.78, 6.50)	0.206
HbA1c (%)	6.40(5.80, 7.30)	6.30(5.80, 7.43)	6.50(5.75, 7.85)	6.30(5.90, 7.00)	6.40(5.70, 7.30)	0.924
HDL-c (mmol/L)	1.15(0.94, 1.41)	1.14(0.89, 1.40)	1.15(0.94, 1.42)	1.15(0.95, 1.41)	1.16(0.97, 1.40)	0.882
LDL-c (mmol/L)	2.42 $\pm$ 0.91	2.55 $\pm$ 0.98	2.24 $\pm$ 0.88	2.47 $\pm$ 0.94	2.33 $\pm$ 0.80	0.174
Total cholesterol (mmol/L)	4.11 $\pm$ 1.11	4.23 $\pm$ 1.11	3.87 $\pm$ 1.09	4.14 $\pm$ 1.14	4.09 $\pm$ 1.05	0.593
Creatinine (mg/dL)	70.50(59.00, 88.00)	71.50(62.00, 83.25)	71.00(57.50, 89.50)	69.5(56.00, 88.75)	70.00(59.00, 95.00)	0.689
Albumin (g/L)	37(33,39)	37(35,40) <sup>a</sup>	37(33,39) <sup>ab</sup>	37(34,40) <sup>a</sup>	35(32,38) <sup>b</sup>	<0.001
25-OH-VD3	14.95(10.22,23.90)	17.90(10.83,26.18)	14.40(8.88,22.73)	14.95(10.80,25.50)	14.25(9.68,22.50)	0.393
CFS-09	5.00(4.00, 6.00)	4.00(3.00, 5.00) <sup>c</sup>	5.00(4.00, 6.00) <sup>b</sup>	5.00(4.00, 6.00) <sup>bc</sup>	6.00(5.00, 6.00) <sup>a</sup>	<0.001

**Table 2** Comparison of IC stratified by sarcopenia and osteoporosis classification. Data are presented as median (interquartile range). *IC* Intrinsic capacity, *MMSE* Mini-Mental state examination, *MNA-SF* Mini nutritional Assessment-Short form, *SPPB* Short physical performance battery, *GDS-15* Geriatric depression Scale-15

	Normal (n=125)	Sarcopenia (n=67)	Osteoporosis (n=149)	Osteosarcopenia (n=120)	P-value
Total IC score	8.00(6.00, 9.00) <sup>a</sup>	7.00(5.00, 7.00) <sup>b</sup>	7.00(5.00, 8.00) <sup>ab</sup>	5.00(3.00, 6.00) <sup>c</sup>	< 0.001
MMSE score	26.00(24.50, 28.00) <sup>a</sup>	26.00(22.00, 28.00) <sup>a</sup>	27.00(23.00, 28.00) <sup>a</sup>	23.00(19.00, 27.00) <sup>b</sup>	< 0.001
MNA-SF score	12.50(10.00, 14.00) <sup>a</sup>	11.00(7.00, 13.00) <sup>b</sup>	12.00(10.00, 14.00) <sup>a</sup>	9.00(7.00, 12.00) <sup>b</sup>	< 0.001
SPPB score	9.00(7.00, 11.00) <sup>a</sup>	7.00(3.00, 9.00) <sup>b</sup>	8.00(4.00, 10.00) <sup>b</sup>	3.00(0.00, 6.00) <sup>c</sup>	< 0.001
GDS-15 score	3.00(2.00, 5.00) <sup>b</sup>	4.00(2.00, 8.00) <sup>ab</sup>	4.00(2.00, 7.00) <sup>ab</sup>	5.00(2.00, 8.00) <sup>a</sup>	0.003
Sense	1.00(1.00, 2.00)	1.00(1.00, 1.00)	1.00(1.00, 1.00)	1.00(0.00, 2.00)	0.153

Additionally, both the osteosarcopenia and sarcopenia groups had lower vitality domain scores than the normal and osteoporosis groups. In contrast, the osteosarcopenia group had higher scores in the GDS-15 compared to the normal group. Regarding the sensory domain, no significant differences were observed among the four groups.

#### Associations between IC and the status of sarcopenia and osteoporosis

We explored the relationship between IC domains and osteosarcopenia constituents (Fig. 2). The results of the logistic regression analysis revealed several significant associations: Higher cognition was significantly associated with a lower risk of osteosarcopenia (OR: 0.871, 95% CI: 0.808–0.933). Higher vitality was significantly associated with a lower risk of both sarcopenia (OR: 0.820, 95% CI: 0.725–0.920) and osteosarcopenia (OR: 0.736, 95% CI: 0.648–0.826). Higher locomotion was significantly associated with a lower risk of sarcopenia (OR: 0.841, 95% CI: 0.764–0.920), osteoporosis (OR: 0.901, 95% CI: 0.832–0.972), and osteosarcopenia (OR: 0.699, 95% CI: 0.629–0.767). Higher psychological domain was significantly associated with a higher risk of sarcopenia (OR: 1.140, 95% CI: 1.030–1.270), osteoporosis (OR: 1.130, 95% CI: 1.030–1.240), and osteosarcopenia (OR: 1.200, 95% CI: 1.100–1.330). Higher sensory domain was significantly associated with a lower risk of osteosarcopenia (OR: 0.633, 95% CI: 0.417–0.950). Additionally, in Table 3, a higher total IC score was significantly associated with reduced risks of sarcopenia (OR: 0.750, 95% CI:

0.612–0.907), osteoporosis (OR: 0.844, 95% CI: 0.714–0.990), and osteosarcopenia (OR: 0.536, 95% CI: 0.433–0.646). These significant relationships persisted in model 2, further validating the robustness of the findings.

#### Subgroup analysis

To further explore the relationship between IC and osteosarcopenia, we performed a subgroup analysis. Higher levels of IC were consistently associated with lower prevalence of osteosarcopenia across all examined subgroups, including age, gender, smoking, BMI, stroke, diabetes, and hypertension. These findings are detailed in Supplementary Fig. 1. The results indicated that there were no significant interactions between different subgroups ( $P > 0.05$ ).

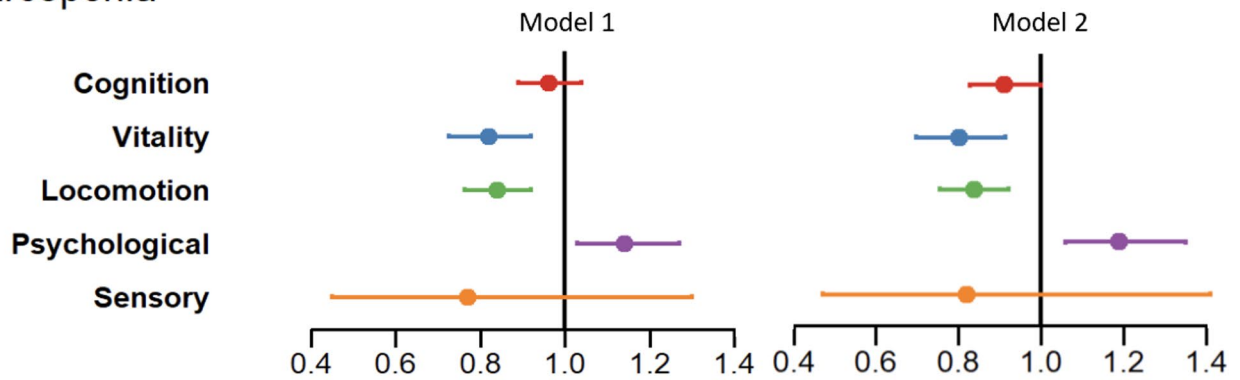
#### Discussion

Our study is the first to explore the relationship between IC domains and osteosarcopenia. The osteosarcopenia group exhibited the lowest scores in the total IC score, locomotion and cognition when compared to the other three groups. Multivariate analyses revealed that cognition and sense were associated with osteosarcopenia, while vitality showed dual associations with sarcopenia and osteosarcopenia. Notably, locomotion and psychological domain demonstrated association with sarcopenia, osteoporosis, and osteosarcopenia. Total IC score was associated with sarcopenia, osteoporosis, and osteosarcopenia, with findings remaining robust in subgroup stratification. These significant relationships persisted after adjustment for confounding variables. These results position IC evaluation as a strategic intervention node for mitigating age-related musculoskeletal decline through comprehensive geriatric assessments.

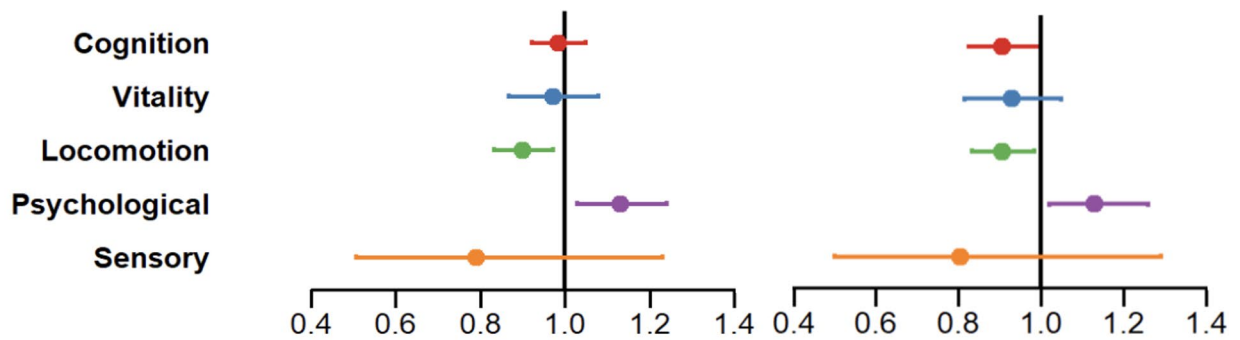
In a study involving 885 older adults, the prevalence of osteosarcopenia was 19.2% [18]. In our study, the prevalence of osteosarcopenia was slightly higher at 26%. This discrepancy may be attributed to our focus on older adults attending a hospital, which likely skews the prevalence higher than that observed in community-dwelling older adults. A meta-analysis encompassing 15,062 patients revealed that the prevalence of osteosarcopenia ranges from 1.5 to 65.7%, with females and older individuals being more susceptible [19]. This aligns with our findings, as the univariate analysis indicated that, compared to the normal group, the osteosarcopenia group had a higher proportion of females and a greater mean age.

Existing literature consistently supports the association between IC domains and osteosarcopenia, aligning with our findings. Specifically, research has demonstrated that locomotion, vitality, and cognition domains significantly correlate with sarcopenia components [9]. Exercise has been proven to improve sarcopenia through a variety of

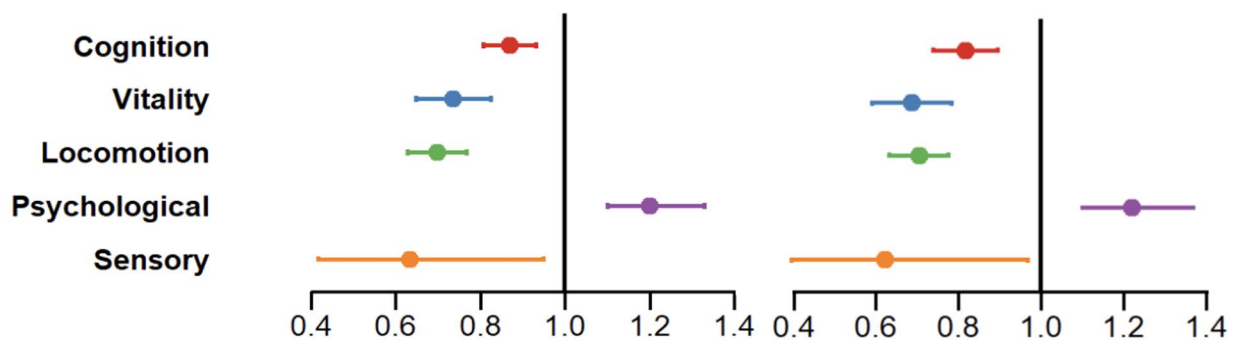
### Sarcopenia



### Osteoporosis



### Osteosarcopenia



**Fig. 2** Multivariate logistic regression examining the associations between IC domains and sarcopenia, osteoporosis, osteosarcopenia. Model 1 was unadjusted. Model 2 was adjusted by sex, education, smoking and number of medications. *IC* Intrinsic capacity

mechanisms and is considered one of the primary strategies for its prevention and treatment. Research has confirmed that exercise can prevent osteoporosis through the epigenetic derepression of Nrf2[20]. Gravitational loading delivers essential mechanical stimuli to the

skeleton through muscular transmission, thereby maintaining bone density [2]. This mechanobiological relationship explains why physical inactivity associated with aging induces concurrent atrophy of muscle and bone tissue, whereas mechanical loading exerts hypertrophic

**Table 3** Logistic regression examining the associations between total IC score and sarcopenia, osteoporosis, osteosarcopenia. Model 1 was unadjusted. Model 2 was adjusted by sex, education, smoking and number of medications. OR Odds ratio, CI Confidence interval, IC Intrinsic capacity

	Sarcopenia		Osteoporosis		Osteosarcopenia	
	OR (95% CI)	P-value	OR (95% CI)	P-value	OR (95% CI)	P-value
Total IC score						
Model 1	0.750(0.612–0.907)	0.004	0.844(0.714–0.990)	0.041	0.536(0.433–0.646)	<0.001
Model 2	0.713(0.570–0.876)	0.002	0.819(0.670–0.992)	0.045	0.498(0.389–0.616)	<0.001

effects on muscles while stimulating osteogenesis in bones [2]. Our result showed albumin in osteosarcopenia group was lower than normal group. Elderly individuals suffering from malnutrition often experience a decline in muscle mass and strength, as well as reduced bone density, making them more susceptible to osteosarcopenia [18]. Musculoskeletal metabolism demonstrates interdependence: Amino acids govern muscle protein turnover while simultaneously supporting bone matrix formation through collagen synthesis [21]. This metabolic synergy is nutritionally modulated through insulin-like growth factor 1-mediated regulation of cellular proteins and enhanced calcium bioavailability, collectively governing tissue anabolism [2]. Pathway analysis within the Structural Equation Model confirmed that the negative impact of cognitive decline on sarcopenia was mediated by nutritional status [22]. Cognitive impairment may initially lead to insufficient physical activity, which in turn can cause a decline in muscle mass and strength, and ultimately result in reduced physical function. Individuals with cognitive impairment were at a significantly increased risk of developing osteoporosis ( $P < 0.001$ ), with Alzheimer's disease patients being 1.7 times more likely to have osteoporosis than the control group ( $P < 0.001$ ) [23]. Therefore, good nutrition and cognition can mitigate the progression of osteosarcopenia.

In our result, psychological domain also was significantly associated with osteosarcopenia. A significant bidirectional relationship has been established between sarcopenia and depression [24]. When depression serves as the exposure factor, the risk of developing sarcopenia significantly increases [24]. Bone morphogenetic proteins and brain-derived neurotrophic factor, which play crucial roles in depression, may also impact muscle health, thereby potentially triggering sarcopenia [25]. A study revealed that in individuals with depression, the expression of miR-21 in osteoblasts was increased, which in turn activated osteoclasts, thereby inducing osteoporosis [18]. Research indicated that visual impairment was independently associated with low muscle mass, while both visual and hearing impairments are independently linked to slow gait speed, thereby increasing the likelihood of developing sarcopenia [26]. The decline in auditory and visual functions within sensory domain of the elderly may affect motor coordination, leading to reduced

activity levels, which in turn can accelerate muscle loss and decrease bone density.

The mechanostat theory posits a dynamic equilibrium where muscular loading exceeding biomechanical thresholds triggers bone formation over resorption [27]. Muscle-derived anabolic effectors (insulin-like growth factor-1, osteocalcin, irisin) and catabolic regulators (myostatin) form a bidirectional crosstalk with skeletal osteokines (osteocalcin, sclerostin) that reciprocally modulate muscle protein dynamics [19]. Our analysis revealed a significant inverse correlation between total IC scores and osteosarcopenia, aligning with prior evidence that compromised IC metrics independently predict sarcopenia risk [9]. Higher IC scores corresponded to reduced risks of sarcopenia, osteoporosis, and osteosarcopenia, suggesting that early identification of IC decline enables multidisciplinary interventions to mitigate disease progression. Mechanistically, progressive resistance training combined with targeted nutritional support emerges as a cornerstone in osteosarcopenia management [2]. These findings elucidate why structured exercise programs paired with nutrient supplementation (protein, vitamin D, calcium) demonstrate therapeutic efficacy against osteosarcopenia [28]. A multidimensional approach integrating physical rehabilitation, sensory optimization (vision/hearing), and cognitive-psychological interventions may further prevent or reverse musculoskeletal deterioration.

This study has some limitations. Firstly, there are no established diagnostic criteria for osteosarcopenia currently, we defined osteosarcopenia as the coexistence of osteoporosis and sarcopenia, not including osteopenia. Osteopenia (T-score between  $-1.0$  and  $-2.5$ ) serves as a precursor to osteoporosis. Excluding individuals with osteopenia may overlook the early signals of musculoskeletal comorbidities, potentially biasing study results towards the characteristics of severe osteosarcopenia groups. This exclusion could also undermine the generalizability of research conclusions in community health management. Future studies should conduct stratified analyses to examine the interactions between different bone density statuses (normal, osteopenia, osteoporosis) and sarcopenia, thereby enhancing the application of the IC assessment system in muscle-skeletal health management. Additionally, the use of self-reported sensory

assessments rather than instrument-based measurements in our study may introduce potential biases.

## Conclusion

Total IC score was associated with sarcopenia, osteoporosis, and osteosarcopenia. Cognition and sense were associated with osteosarcopenia, while vitality showed dual associations with sarcopenia and osteosarcopenia. Notably, locomotion and psychological domain demonstrated association with sarcopenia, osteoporosis, and osteosarcopenia.

## Supplementary Information

The online version contains supplementary material available at <https://doi.org/10.1186/s12877-025-06424-4>.

Supplementary Material 1.

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Not applicable.

## Authors' contributions

XQ consulted literature and wrote the manuscript; LG and QP designed the review; LZ, FM and WW assisted with writing and revising the manuscript. All authors contributed to the article and approved the submitted version.

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## Data availability

No datasets were generated or analysed during the current study.

## Declarations

### Ethics approval and consent to participate

Ethical approval for this study was obtained from the Medical Ethics Committee of Beijing Hospital (Approval Number: 2024BJYYEC-KY083-02).

### Consent for publication

Not applicable.

### Competing interests

The authors declare no competing interests.

### Clinical trial number

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