

Joint Sarcopenia-Frailty Phenotypes and Subsequent Falls and Hip Fracture in Older Chinese Adults: A Seven-Year CHARLS Study

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Abstract

Objective

To determine whether joint sarcopenia-frailty phenotypes differentially predict first observed falls and hip fracture in older Chinese adults and whether coexistence confers risk beyond either condition alone.

Methods

We analyzed the China Health and Retirement Longitudinal Study using 2011 as baseline and 2013, 2015, and 2018 as follow-up visits. Adults aged ≥ 60 years with a classifiable joint phenotype, no baseline report of the corresponding outcome, and at least one subsequent outcome assessment were included. Four phenotypes were defined: neither condition, sarcopenia only, frailty only, and sarcopenia plus frailty. Discrete-time complementary log-log models estimated hazard ratios (HRs) with 20-fold multiple imputation. Standardized 7-year risks, risk differences, and multiplicative and additive interactions were also estimated.

Results

The falls cohort included 3,987 participants with 1,415 events; the hip-fracture cohort included 4,884 participants with 197 events. Compared with neither condition, adjusted HRs (95% CIs) for falls were 1.02 (0.89–1.16) for sarcopenia only, 1.45 (1.20–1.75) for frailty only, and 1.40 (1.15–1.69) for coexisting sarcopenia and frailty. Corresponding HRs for hip fracture were 1.23 (0.87–1.75), 1.97 (1.29–3.01), and 1.91 (1.13–3.21). Standardized risks were 37.8%, 38.3%, 49.5%, and 48.3% for falls and 3.8%, 4.6%, 7.3%, and 7.0% for hip fracture, respectively. Multiplicative interactions were not significant ($P = 0.709$ and $P = 0.470$), and additive-interaction confidence intervals included zero for both outcomes. Key conclusions were unchanged after additional BMI adjustment.

Conclusions

Frailty, with or without sarcopenia, identified older adults at increased risk of falls and hip fracture, whereas sarcopenia alone did not show a clear association in the joint-phenotype framework. Coexistence did not demonstrate excess risk beyond that expected from the two component states. These findings support joint risk stratification but not statistical synergy.

Introduction

Falls are a major cause of injury, loss of independence, and health-care use in older adults, and hip fracture is among their most consequential outcomes^[1–3]. Identifying upstream vulnerability before an event occurs is therefore central to healthy-aging and fracture-prevention strategies. Muscle weakness,

low muscle mass, and impaired physical performance may compromise postural recovery, whereas frailty reflects broader depletion of physiologic reserve across multiple organ and functional domains^[4–6].

Sarcopenia and frailty overlap but are not interchangeable. Sarcopenia is centered on skeletal muscle quantity and function, while deficit-accumulation frailty summarizes multisystem health deficits^[4, 7, 8]. Meta-analytic evidence links sarcopenia with falls and fractures and frailty with both falls and fractures^[9, 10]. Recent CHARLS studies have also reported longitudinal associations of sarcopenia with falls and hip fracture and of frailty with hip fracture^[11–13]. However, binary analyses of either condition alone cannot determine whether risk is driven mainly by sarcopenia, frailty, or their coexistence.

A four-category joint phenotype can separate these contributions, but a higher event rate in the coexisting group is not itself evidence of interaction. Formal interaction analyses and absolute-risk estimates are needed to determine whether coexistence adds risk beyond the component states^[14]. Using repeated CHARLS follow-up, we therefore compared four sarcopenia-frailty phenotypes with first observed falls and hip fracture, estimated standardized cumulative risks, and evaluated multiplicative and additive interaction. We hypothesized that frailty-related phenotypes would carry higher risk and tested whether coexistence produced an additional joint effect.

Methods

Study design and participants

The China Health and Retirement Longitudinal Study (CHARLS) is an ongoing longitudinal survey of middle-aged and older adults in China using multistage probability sampling. Baseline interviews were conducted in 2011, with subsequent waves in 2013, 2015, 2018, and 2020^[15]. We prespecified 2011 as the exposure baseline and 2013, 2015, and 2018 as the primary outcome visits. Reporting followed the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement^[16].

The primary population was restricted to participants aged ≥ 60 years with a classifiable joint sarcopenia-frailty phenotype. Outcome-specific cohorts were created. For each endpoint, participants with the corresponding outcome already reported at baseline were excluded, and at least one observed follow-up assessment in 2013, 2015, or 2018 was required. Participants remained at risk until the first observed event or their last available outcome visit. This approach retained participants with partial follow-up rather than requiring all three outcome waves to be complete.

Sarcopenia and frailty

Sarcopenia was operationalized according to the Asian Working Group for Sarcopenia 2019 framework^[17]. Handgrip strength was the maximum valid measurement from either hand; low strength

was defined as < 28 kg in men and < 18 kg in women. Walking speed was calculated from the 2.5-m walking test, with < 1.0 m/s classified as low physical performance. Because CHARLS did not provide direct dual-energy X-ray absorptiometry measurements of appendicular skeletal muscle mass (ASM), ASM was estimated using a Chinese anthropometric equation: $ASM (kg) = 0.193 \times \text{weight} (kg) + 0.107 \times \text{height} (cm) - 4.157 \times \text{sex} - 0.037 \times \text{age} (years) - 2.631$, where sex = 1 for men and 2 for women^[18]. Skeletal muscle index was ASM/height^2 ; low muscle mass was defined as < 7.0 kg/m² in men and < 5.7 kg/m² in women. Sarcopenia required low muscle mass plus low grip strength and/or low walking speed.

Frailty was measured using the prespecified 22-item deficit-accumulation index. The index covered 14 chronic conditions, self-rated health, ADL, IADL, depressive symptoms, cognition, vision, hearing, and sleep. Each deficit was scaled from 0 to 1, the index was calculated when at least 80% of items were available, and frailty was defined as an index ≥ 0.25 . For the expanded wave-1 cohort used in the present analysis, the joint phenotype was reconstructed from the baseline CHARLS variables and validated against the available original RDS-derived phenotype among overlapping participants; agreement was 98.5%.

Outcomes

The two outcomes were the first observed self-reported fall and first observed self-reported hip fracture during follow-up. Because the questionnaires identify events only at study visits rather than exact event dates, 2013, 2015, and 2018 were treated as discrete risk intervals corresponding to approximately 2-, 2-, and 3-year periods. Participants exited the risk set after their first observed event. Accordingly, outcomes are described as first observed self-reported events rather than medically verified exact incident dates.

Baseline covariates

Prespecified covariates were age, sex, urban or rural residence, education, marital status, current smoking, and current drinking. Age was modeled using a natural spline with three degrees of freedom. Body mass index (BMI) was not included in the primary model because weight and height contribute directly to the ASM prediction equation; adjustment for BMI could therefore constitute overadjustment. BMI was added in a dedicated sensitivity model. Chronic diseases, ADL/IADL limitations, depressive symptoms, cognition, sensory deficits, and sleep were not separately adjusted because they contribute to the frailty index and their inclusion would mechanically adjust for components of the exposure. Given the marked between-phenotype BMI imbalance at baseline, the BMI-adjusted specification was treated as a targeted robustness analysis rather than as the primary causal model.

Statistical analysis

Baseline characteristics were summarized across the four joint phenotypes using means with standard deviations or n (%). Standardized mean differences (SMDs) were reported descriptively rather than using baseline P values as balance tests. Separate person-period datasets were constructed for falls and hip fracture. Complementary log-log regression with visit-specific baseline hazards and a log interval-length offset was used for discrete-time event analysis; exponentiated coefficients were interpreted as discrete-time HR approximations^[19]. Robust standard errors were clustered by CHARLS community.

Missing baseline covariates were handled using 20 multiply imputed datasets with chained equations, and coefficients and variances were pooled with Rubin rules^[20]. Exposure components and outcomes were not imputed. For absolute effects, the fitted model was standardized to the same covariate distribution under each of the four joint phenotypes to estimate 7-year cumulative risk, risk differences versus neither condition, and excess events per 1,000 participants.

Interaction was evaluated on two scales. Multiplicative interaction was tested by fitting sarcopenia, frailty, and their product term. Additive interaction was estimated from standardized risks as $\text{Risk}_{11} - \text{Risk}_{10} - \text{Risk}_{01} + \text{Risk}_{00}$ ^[14]. Confidence intervals for standardized risks and additive interaction were obtained with 500 community-cluster bootstrap resamples. Prespecified sensitivity analyses included complete cases, additional BMI adjustment, restriction to participants with all three follow-up waves, extension to adults aged ≥ 45 years, inverse-probability-of-follow-up weighting (IPCW) with weights truncated at the 1st and 99th percentiles, and extension of hip-fracture follow-up through 2020^[21]. Analyses were conducted in R; all tests were two-sided. Because death is a potential competing event, mortality-related variables were additionally inspected for suitability for competing-risk analysis; a Fine–Gray model was to be undertaken only if participant-level death status and event timing could be validated.

Ethics

The original CHARLS study was approved by the Peking University Biomedical Ethics Review Committee (IRB00001052-11015), and all participants provided informed consent^[15]. This secondary analysis used de-identified data and involved no direct participant contact.

Results

Participants and joint phenotypes

Among 5,355 participants aged ≥ 60 years with an available baseline joint phenotype, 3,987 were eligible for the falls analysis and 4,884 for the hip-fracture analysis after endpoint-specific baseline exclusions and the requirement of at least one observed follow-up (Fig. 1). The falls cohort had a mean age of 67.5 years; 47.1% were women and 64.0% were rural residents. The four groups included 2,004 participants (50.3%) with neither condition, 1,360 (34.1%) with sarcopenia only, 379 (9.5%) with frailty only, and 244

(6.1%) with both conditions. The corresponding distribution in the hip-fracture cohort was 2,378 (48.7%), 1,636 (33.5%), 527 (10.8%), and 343 (7.0%).

Participants with sarcopenia were older and more often women and rural residents, whereas frailty-related groups had markedly higher frailty-index values (Table 1). BMI was substantially lower in sarcopenia groups, consistent with its role in the anthropometric muscle-mass estimate. Baseline patterns were similar in the hip-fracture cohort (Supplementary Table S1). Only three baseline education values were missing in the falls cohort and four in the hip-fracture cohort; other prespecified covariates were complete (Supplementary Table S3). In the falls cohort, rural residence was reported by 58.0%, 72.2%, 59.1%, and 75.4% across the neither, sarcopenia-only, frailty-only, and coexisting groups, respectively; the between-group BMI imbalance was large (SMD = 1.259).

Table 1
Baseline characteristics of the falls cohort by joint sarcopenia-frailty phenotype

Characteristic	Neither	Sarcopenia only	Frailty only	Sarcopenia + frailty	SMD
Participants, n (%)	2004	1360	379	244	
Age, years	66.16 (5.39)	69.36 (6.88)	66.67 (5.60)	69.89 (6.23)	0.384
Women	715 (35.7)	823 (60.5)	173 (45.6)	167 (68.4)	0.392
Rural residence	1162 (58.0)	982 (72.2)	224 (59.1)	184 (75.4)	
Education					0.360
Illiterate/Primary incomplete	912 (45.5)	907 (66.8)	215 (56.7)	178 (73.0)	
Primary	596 (29.8)	300 (22.1)	103 (27.2)	48 (19.7)	
Middle school	331 (16.5)	98 (7.2)	49 (12.9)	13 (5.3)	
High school or above	164 (8.2)	53 (3.9)	12 (3.2)	5 (2.0)	
Married/partnered	1713 (85.5)	1015 (74.6)	304 (80.2)	174 (71.3)	0.197
Current smoking	696 (34.7)	412 (30.3)	102 (26.9)	72 (29.5)	
Current drinking	719 (35.9)	372 (27.4)	97 (25.6)	51 (20.9)	
Body mass index, kg/m ²	24.75 (3.39)	19.94 (2.07)	25.49 (3.26)	20.06 (2.31)	1.259
Frailty index	0.13 (0.06)	0.13 (0.07)	0.32 (0.06)	0.31 (0.04)	2.173
Data are mean (standard deviation) or n (%), calculated among nonmissing observations. SMD, standardized mean difference. BMI was not included in the primary outcome model because weight and height contribute to the estimated appendicular skeletal muscle mass; BMI was evaluated in sensitivity analysis. The large BMI imbalance (SMD = 1.259) was therefore addressed explicitly in the BMI-adjusted sensitivity model.					

Falls and hip fracture

During follow-up, 1,415 of 3,987 participants (35.5%) had a first observed fall. Crude person-level event proportions were 32.0% in the neither group, 36.8% in sarcopenia only, 42.5% in frailty only, and 45.9% in the coexisting group. In the primary multiply imputed discrete-time model, sarcopenia only was not

clearly associated with falls (HR 1.02, 95% CI 0.89–1.16). Frailty only (HR 1.45, 95% CI 1.20–1.75) and sarcopenia plus frailty (HR 1.40, 95% CI 1.15–1.69) were associated with higher risk (Table 2; Fig. 2).

Table 2
Joint sarcopenia-frailty phenotypes, adjusted relative risk, and standardized absolute risk

Outcome	Joint phenotype	Events / n	HR (95% CI)	Standardized risk, % (95% CI)	Risk difference, pp (95% CI)
Falls	Neither	642 / 2004	1.00 (reference)	37.8 (35.7–39.9)	0.0 (reference)
Falls	Sarcopenia only	500 / 1360	1.02 (0.89–1.16)	38.3 (35.2–41.1)	0.5 (–3.4–4.3)
Falls	Frailty only	161 / 379	1.45 (1.20–1.75)	49.5 (43.1–56.5)	11.7 (5.2–18.9)
Falls	Sarcopenia + frailty	112 / 244	1.40 (1.15–1.69)	48.3 (42.0–54.3)	10.4 (4.1–16.8)
Hip fracture	Neither	70 / 2378	1.00 (reference)	3.8 (2.9–4.7)	0.0 (reference)
Hip fracture	Sarcopenia only	74 / 1636	1.23 (0.87–1.75)	4.6 (3.5–5.8)	0.9 (–0.7–2.4)
Hip fracture	Frailty only	30 / 527	1.97 (1.29–3.01)	7.3 (4.8–9.8)	3.5 (1.0–6.1)
Hip fracture	Sarcopenia + frailty	23 / 343	1.91 (1.13–3.21)	7.0 (4.1–10.2)	3.3 (0.3–6.7)

HRs are from 20-fold multiply imputed complementary log-log models with visit-specific baseline risk and interval-length offset, adjusted for age (natural spline, 3 degrees of freedom), sex, residence, education, marital status, current smoking, and current drinking, with community-cluster robust standard errors. Standardized-risk confidence intervals are from 500 complete-case community-cluster bootstrap resamples. Multiplicative sarcopenia×frailty interaction: falls HR 0.95 (95% CI 0.72–1.25), $P = 0.709$; hip fracture HR 0.79 (0.41–1.51), $P = 0.470$. pp denotes percentage points. Additive-interaction risk difference: falls – 1.7 percentage points (95% CI – 11.4 to 7.6); hip fracture – 1.1 percentage points (– 5.4 to 2.9).

Hip fracture was first observed in 197 of 4,884 participants (4.0%). Crude person-level event proportions were 2.9%, 4.5%, 5.7%, and 6.7% across the four groups, respectively. Adjusted HRs versus neither condition were 1.23 (95% CI 0.87–1.75) for sarcopenia only, 1.97 (95% CI 1.29–3.01) for frailty only, and 1.91 (95% CI 1.13–3.21) for coexisting sarcopenia and frailty (Table 2; Fig. 2).

Interaction and absolute risk

Formal interaction analyses did not support a joint effect beyond the component states. The sarcopenia×frailty multiplicative interaction HR was 0.95 (95% CI 0.72–1.25; $P = 0.709$) for falls and 0.79 (95% CI 0.41–1.51; $P = 0.470$) for hip fracture. On the absolute scale, additive-interaction risk differences

were – 1.7 percentage points (bootstrap 95% CI – 11.4 to 7.6) for falls and – 1.1 percentage points (95% CI – 5.4 to 2.9) for hip fracture (Supplementary Table S4; Supplementary Figure S2).

Standardized 7-year fall risks were 37.8% for neither condition, 38.3% for sarcopenia only, 49.5% for frailty only, and 48.3% for both conditions (Fig. 3; Supplementary Table S6). Compared with neither condition, this corresponded to approximately 4.9, 116.6, and 104.4 additional falls per 1,000 participants, respectively. Standardized hip-fracture risks were 3.8%, 4.6%, 7.3%, and 7.0%, corresponding to approximately 8.6, 34.8, and 32.7 additional hip fractures per 1,000 participants. Thus, the two frailty-related groups had similar absolute risks, while sarcopenia alone produced little risk separation for falls and only modest separation for hip fracture.

Sensitivity analyses

Findings were stable across alternative analytic specifications (Supplementary Figure S1; Supplementary Table S5). Complete-case and IPCW estimates were nearly identical to the primary estimates. Additional BMI adjustment preserved the increased risks in the frailty-only and coexisting groups; for falls, HRs were 1.45 and 1.38, and for hip fracture they were 1.95 and 2.13, respectively. Requiring complete outcome data at all three follow-up waves reduced sample size and precision but retained the same general pattern; the coexisting hip-fracture estimate became imprecise (HR 1.53, 95% CI 0.80–2.93). Analyses including adults aged ≥ 45 years were also directionally consistent. When hip-fracture follow-up was extended through 2020, HRs were 1.83 (95% CI 1.22–2.75) for frailty only and 2.12 (95% CI 1.37–3.29) for coexistence. Thus, the principal finding that risk elevation was concentrated in frailty-related phenotypes was not materially changed by additional BMI adjustment. Competing-risk analysis was also considered, but the available mortality-related variables did not yield a validated participant-level death indicator with reliable event timing; therefore, a Fine–Gray model was not reported.

Discussion

In this seven-year longitudinal analysis of older CHARLS participants, frailty was the more consistent marker of subsequent falls and hip fracture within the joint sarcopenia-frailty framework. Frailty alone and coexistence were each associated with higher adjusted relative and standardized absolute risks, whereas sarcopenia alone was not clearly associated with either outcome. Importantly, coexistence did not exceed frailty alone in a monotonic manner, and neither multiplicative nor additive interaction supported statistical synergy. The findings therefore favor joint risk stratification while indicating that the stable signal was primarily carried by frailty rather than an extra effect of coexistence.

These results should be interpreted alongside recent CHARLS studies that evaluated sarcopenia as a binary exposure. Yang et al. reported an adjusted HR of 1.32 for incident falls among older adults with sarcopenia, and Huang et al. found a modest longitudinal association between sarcopenia and hip fracture^[12, 22]. A 2026 CHARLS analysis likewise found consistent associations with falls but less stable fracture estimates across conventional adjustment, propensity-score matching, and weighting^[13]. Our

sarcopenia-only estimate does not directly contradict those studies: their sarcopenia groups could include participants who were also frail, whereas our four-category design isolates sarcopenia in the absence of frailty. The attenuation of the sarcopenia-only association after this separation suggests that part of the risk attributed to sarcopenia in binary models may coexist with broader multisystem vulnerability.

The prominent frailty signal is biologically and clinically plausible. A deficit-accumulation frailty index integrates chronic disease, disability, mood, cognition, sensory function, and sleep, all of which may influence balance, activity, environmental awareness, and recovery from perturbation^[4, 23, 24]. Meta-analyses have identified frailty as a predictor of falls and fractures, and a recent CHARLS study found a graded association between frailty index and hip-fracture risk^[25–27]. Notably, a 2026 Korean prospective study examining sarcopenia and physical frailty together found that frailty alone predicted falls and several functional outcomes, whereas sarcopenia alone did not, broadly aligning with the relative pattern seen here despite different frailty and sarcopenia definitions^[28].

The absolute-risk results sharpen the clinical interpretation. Compared with neither condition, frailty alone and coexistence were associated with about 117 and 104 additional falls per 1,000 participants and about 35 and 33 additional hip fractures per 1,000 participants over seven years. These differences were substantially larger than those for sarcopenia alone. Yet the confidence intervals for formal additive interaction crossed zero, so a high absolute risk in the coexisting group should not be labeled synergistic. In practice, concurrent assessment of muscle health and frailty may still be useful because it distinguishes a large sarcopenia-only group with comparatively modest risk from the smaller frailty-related groups with substantially higher risk. Rural residence was more common in the sarcopenia-containing groups, but because residence was adjusted for in all primary models and no stable independent rural effect was established, rurality should be viewed here as a contextual baseline difference rather than a principal risk factor.

Several strengths support the analysis. We used endpoint-specific cohorts and retained partial follow-up information rather than excluding participants unless all outcome waves were complete. Discrete-time models respected the fact that event timing was observed only at visits. Missing covariates were handled with multiple imputation; IPCW evaluated differential follow-up; and conclusions were examined across complete-case, BMI-adjusted, complete-wave, broader-age, and extended hip-fracture analyses. Finally, formal interaction and standardized absolute risks avoided equating the highest crude event proportion with biological or statistical synergy. Importantly, the marked baseline BMI imbalance did not materially alter the frailty-related associations when BMI was added to the model, supporting robustness of the main inference while recognizing the close mathematical relation between BMI and anthropometrically estimated ASM.

Limitations remain. Falls and hip fractures were self-reported and exact event dates were unavailable. ASM was estimated from anthropometry rather than measured directly by DXA or bioimpedance; recent methodological commentary has cautioned that this equation may misclassify muscle mass in older

CHARLS participants, so sarcopenia-related estimates require particular caution^[29]. Some frailty components are themselves strong predictors of falls and fracture, meaning the frailty association reflects a broad vulnerability construct rather than a single mechanism. Residual confounding remains possible. The absence of applicable survey weights and design strata means estimates should not be interpreted as nationally weighted incidence. Finally, observational associations cannot establish that screening or intervention would reduce events. Death is a plausible competing event during seven years of follow-up. Although mortality-related variables were available in a supplementary derivative dataset, their status/time values could not be validated as reliable participant-level competing-event information; we therefore did not force a Fine–Gray analysis, and bias from unaccounted mortality cannot be excluded.

Conclusions

Among older CHARLS participants, frailty with or without sarcopenia was associated with higher subsequent risk of first observed falls and hip fracture, whereas sarcopenia alone showed no clear association after joint classification. Coexisting sarcopenia and frailty did not demonstrate additional multiplicative or additive risk beyond the component states. Joint assessment may improve clinical risk stratification, but the present data support frailty-driven vulnerability rather than statistical synergy.

Declarations

Ethics approval and consent to participate:

The original CHARLS study was approved by the Peking University Biomedical Ethics Review Committee (IRB00001052-11015), and all participants provided informed consent. This secondary analysis used de-identified data and involved no direct participant contact.

Consent for publication:

Not applicable.

Clinical trial number:

not applicable.

Availability of data and materials:

CHARLS data are available to registered users through the official CHARLS data platform subject to its data-use requirements. The analysis code and aggregate derived results can be shared with the submission materials; participant-level data should not be redistributed.

Competing interests:

No potential conflicts of interest are reported in this working manuscript. This statement should be confirmed by all authors before submission.

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Authors' contributions:

All authors participated in the conception and design of this study. Xiantao Feng , Shi Chen, and Fuwei Ban jointly determined the title, collected and reviewed the literature, and designed the paper's framework. Xiantao Feng and Zhipeng Huang were responsible for data organization and analysis. The initial draft was written by Xiantao Feng and Shi Chen, while Fuwei Ban and Pengyong Xu handled proofreading. All authors provided feedback and revisions on earlier versions. All authors read and approved the final manuscript.

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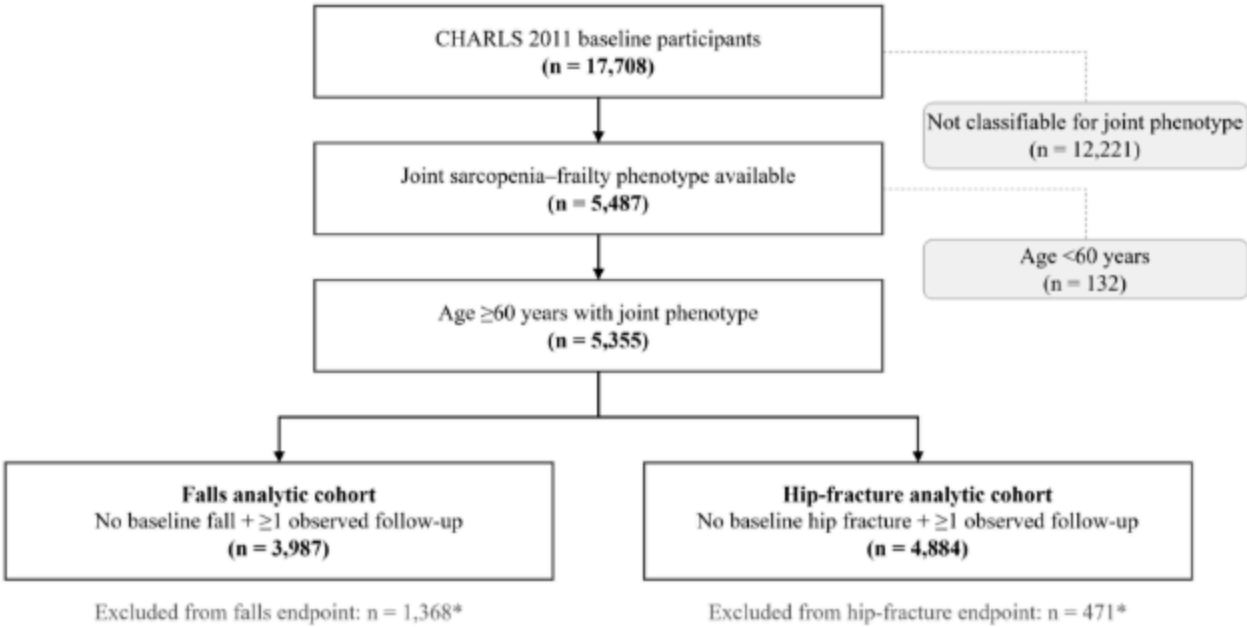
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Figures



*The available audit output combines two endpoint-specific exclusion reasons: a baseline history of the endpoint and no observed follow-up for that endpoint; these reasons cannot be separated further from the exported audit table.

Figure 1
Participant selection for the endpoint-specific falls and hip-fracture cohorts. CHARLS, China Health and Retirement Longitudinal Study.

Joint sarcopenia-frailty phenotype and outcomes Multiple-imputation discrete-time complementary log-log models

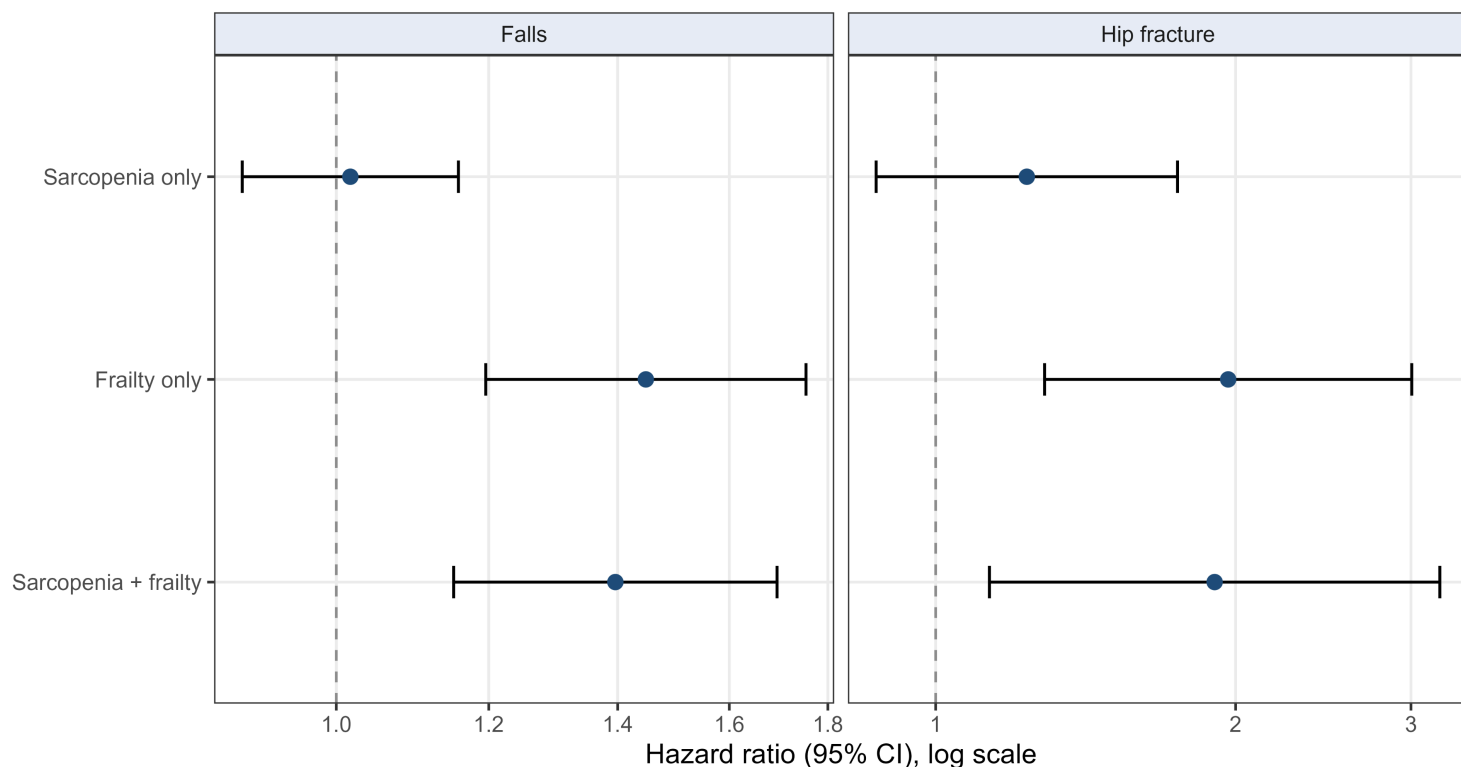
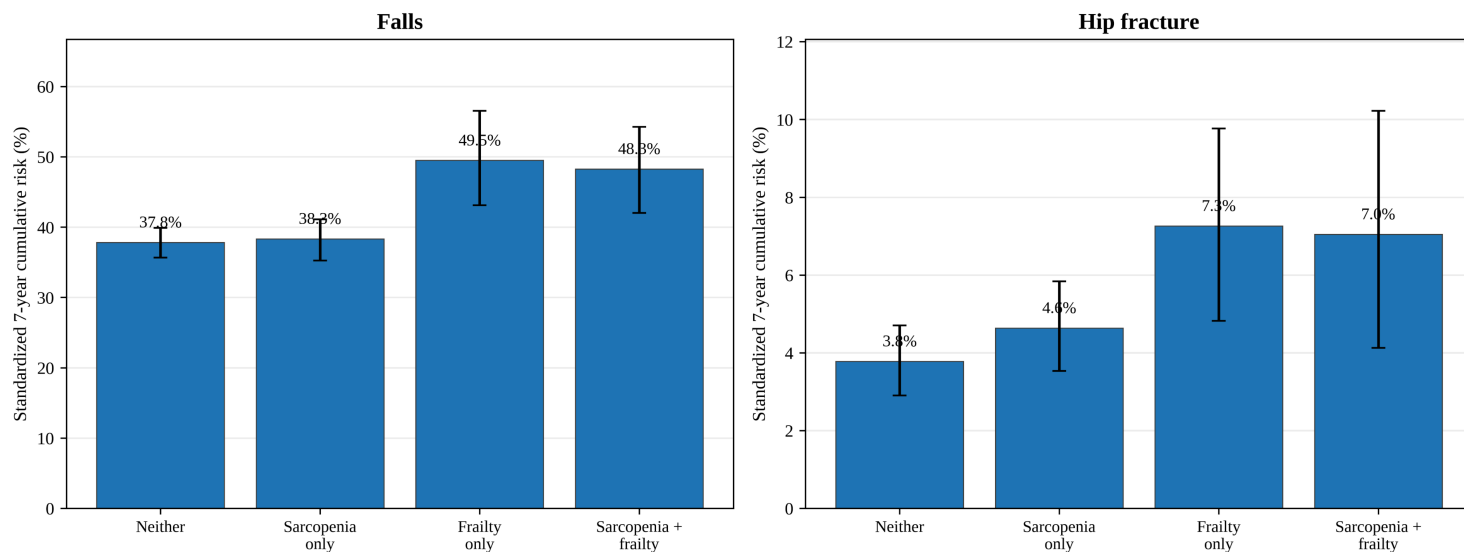


Figure 2

Adjusted associations of joint sarcopenia-frailty phenotypes with first observed falls and hip fracture. Points and bars show hazard ratios and 95% confidence intervals from the primary 20-fold multiply imputed complementary log-log models; neither sarcopenia nor frailty is the reference. Models include visit-specific baseline risk, interval-length offset, age natural spline (3 degrees of freedom), sex, residence, education, marital status, current smoking, and current drinking, with community-cluster robust standard errors.

Standardized absolute risks by joint sarcopenia–frailty phenotype



Error bars are 95% confidence intervals from 500 community-cluster bootstrap resamples.

Figure 3

Standardized 7-year cumulative risks of first observed falls and hip fracture under each joint sarcopenia–frailty phenotype. Bars show standardized risk estimates from the primary model; error bars show 95% confidence intervals from 500 community-cluster bootstrap resamples.

Supplementary Files

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