

Two Methods of Handgrip Strength Assessment in Sarcopenia Evaluation: Associations with in-Hospital Mortality in Older Adults

Eliana Hanna Deschamps¹, François R Herrmann², David De Macedo Ferreira³, Mauro Silva², Christophe E Graf², Aline Mendes²

¹Division of Internal Medicine and Rehabilitation Beau-Séjour, Department of Rehabilitation and Geriatrics, University Hospitals of Geneva and University of Geneva, Geneva, Switzerland; ²Division of Geriatrics and Rehabilitation, Department of Rehabilitation and Geriatrics, University Hospitals of Geneva and University of Geneva, Geneva, Switzerland; ³Division of Rehabilitation Loëx/Joli-Mont, Department of Rehabilitation and Geriatrics, University Hospitals of Geneva and University of Geneva, Geneva, Switzerland

Correspondence: Aline Mendes, Division of Geriatrics and Rehabilitation, Department of Rehabilitation and Geriatrics, University Hospitals of Geneva and University of Geneva, Chemin du Pont-Bochet 3, Thônex, Geneva, 1226, Switzerland, Tel +41 795538365, Email aline.mendes@hug.ch

Background: Handgrip strength (HGS) is a key diagnostic tool for sarcopenia, yet the comparative prognostic value of the hydraulic dynamometer and pneumatic vigorimeter in hospitalized older adults remains unclear. This study is the first to examine the vigorimeter as a predictor of in-hospital mortality in this setting.

Methods: This prospective cohort study included 376 hospitalized older adults (mean age: 82.7 years) across acute, rehabilitation, and long-term care wards. HGS was assessed using both the dynamometer and vigorimeter, applying two sets of cut-offs per instrument. Sarcopenia was confirmed using bioelectrical impedance analysis to calculate the fat-free mass index (FFMI), with four diagnostic criteria combining HGS and FFMI thresholds. Associations between HGS, sarcopenia, and mortality were evaluated using logistic regression and Cox proportional hazards models, with Kaplan-Meier curves illustrating survival differences.

Results: Higher HGS measured by the vigorimeter was independently associated with reduced in-hospital mortality (OR 0.96, 95% CI 0.93–0.98, $p = 0.001$), whereas no significant association was found for dynamometer-measured HGS. Confirmed sarcopenia was significantly associated with mortality for two diagnostic criteria (criterion 2: vigorimeter with DO-HEALTH1 cut-offs: OR 1.77, 95% CI 1.01–3.10, $p = 0.047$; criterion 4: vigorimeter with DO-HEALTH2 cut-offs: OR 1.76, 95% CI 1.01–3.07, $p = 0.048$), although no significant association was observed with time-to-mortality. Kaplan-Meier curves demonstrated significant survival differences only for vigorimeter-based HGS cut-offs ($p = 0.04$). Male sex and falls during hospitalization were associated with increased mortality, while admission to rehabilitation or long-term care wards was associated with reduced mortality.

Conclusion: Vigorimeter-based HGS, especially using DO-HEALTH1 cut-offs, demonstrated superior prognostic value for in-hospital mortality compared to the dynamometer. These findings support the clinical utility of the vigorimeter for risk stratification and care planning in hospitalized older adults, particularly in settings where subtle neuromuscular deficits may influence outcomes.

Plain Language Summary: Sarcopenia is a disease that leads to the loss of muscle mass and strength, increasing the risk of falls, disability, and death in older adults. Detecting sarcopenia early is essential to better support hospitalized older individuals.

One simple way to assess muscle strength is by measuring how forcefully a person can hold or compress an object. Two tools are commonly used in hospitals: the dynamometer, which measures how strongly someone can grasp a rigid handle, and the vigorimeter, which records the pressure when the person compresses a soft rubber ball filled with air.

In this study, we assessed 376 hospitalized older adults, with an average age of 82 years. We compared grip strength measured by both devices, combined with muscle mass evaluations, to see which method better predicted survival during hospitalization.

We found that lower strength measured with the vigorimeter was significantly associated with a higher risk of death. Strength measured with the dynamometer showed no such association. One reason may be that the vigorimeter captures subtle muscle weakness more effectively, as it accommodates a broader range of hand and finger movements, making it more suitable for frail older patients.

These findings suggest that using the vigorimeter could improve how healthcare teams identify older adults at higher risk and adapt care to their needs.

Keywords: key-words, sarcopenia, mortality, fat-free mass index, handgrip strength, dynamometer, vigorimeter

Introduction

Sarcopenia, the progressive loss of muscle mass, strength, and function, is a key determinant of health outcomes in older adults, contributing to increased risks of disability, hospitalization, and mortality. Its prevalence ranges from approximately 10% among community-dwelling adults to over 50% in hospitalized or institutionalized individuals.^{1–3} The 2018 European Working Group on Sarcopenia in Older People (EWGSOP2) guidelines refined the definition and diagnostic criteria for sarcopenia, emphasizing early detection and a staged diagnostic process, with a stepwise approach, starting with screening for sarcopenia which define “probable” sarcopenia, followed by the confirmation of diagnosis.⁴

Handgrip strength (HGS) is a key metric for identifying probable sarcopenia.⁵ The Jamar[®] dynamometer and the Martin[®] vigorimeter are two widely used tools for measuring HGS, differing in their methodologies. The dynamometer quantifies isometric grip strength in kilograms (kg), emphasizing peak force, while the vigorimeter measures dynamic grip pressure in kilopascals (kPa), capturing broader hand and finger muscles dynamics.⁶ Both devices are validated in older populations and demonstrate strong correlations, underscoring their reliability.⁷

The EWGSOP2 recommends cut-offs of <27 kg for men and <16 kg for women for probable sarcopenia using the dynamometer. For the vigorimeter, population-specific thresholds have been proposed, but no universal cut-offs have been established.^{7–10} Sarcopenia is confirmed through muscle mass measurements, which can be indirectly assessed using bioelectrical impedance analysis (BIA) or other methods such as dual-energy X-ray absorptiometry (DXA) or imaging techniques like MRI and CT scans.^{11–13} Although diagnostic confirmation is mandatory, positive screening should prompt early interventions targeting nutrition and physical activity, even before confirmation, particularly in high-risk populations.

In our study, diagnostic classification followed the EWGSOP2 algorithm, with “probable sarcopenia” based on HGS as the first step. We used four diagnostic criteria combining two HGS thresholds per instrument and a standardized FFMI cut-off. While the prognostic value of low HGS and sarcopenia diagnosis for adverse outcomes is well-established, data on how different HGS measurement tools influence prognostic accuracy in hospitalized older populations remain limited.^{14–17} However, the prognostic value of these measures can be influenced by several factors, including the choice of methods, diagnostic cut-offs, the clinical setting, and the characteristics of the population under study.^{18,19} For instance, in acute care, HGS may be linked to mortality, while in rehabilitation or long-term care, it may indicate recovery potential or chronic decline.^{20,21}

Moreover, to our knowledge, no prior study has examined the prognostic performance of the vigorimeter for in-hospital mortality in a hospitalized geriatric population. This study is therefore the first to explore its utility in acute and post-acute care contexts.

This study aimed to compare two handgrip strength assessment methods (dynamometer and vigorimeter) and four diagnostic criteria for sarcopenia in predicting in-hospital mortality and time-to-mortality among hospitalized older adults across acute, rehabilitation, and long-term care settings. We hypothesized that sarcopenia, particularly when identified using comprehensive diagnostic criteria, and lower muscle strength would be independently associated with increased mortality risk and shorter survival. Additionally, we explored how the choice of measurement method and diagnostic thresholds influenced these associations.

Methods

Design, Setting and Participants

This prospective observational cohort study was conducted at the Department of Rehabilitation and Geriatrics, Geneva University Hospitals (HUG), between April 24 and June 22, 2023. All hospitalized patients across acute, rehabilitation,

and long-term care wards were eligible for inclusion. Patients were followed for mortality outcomes over a period of 300 days using electronic health records and hospital discharge data. Only the first eligible hospitalization was included in the analysis to avoid duplication.

Exclusion criteria included patients receiving end-of-life care on the day of HGS assessment, those with clinical instability, or those unable to perform HGS assessments due to upper limb motor neurological deficits. Clinical instability was defined as requiring continuous vital sign monitoring, oxygen therapy with $\text{FiO}_2 > 35\%$, or ongoing acute interventions precluding safe testing, as judged by the attending physician and study team. No patients were excluded after initial inclusion.

The study protocol was submitted to the Geneva Cantonal Ethics Committee (Commission cantonale d'éthique de la recherche sur l'être humain, CCER), which granted an exemption from formal written consent as the study was classified as a quality improvement initiative. Approval was obtained before study initiation in March 2023. The study was conducted in accordance with the Declaration of Helsinki. Oral consent was obtained from all participants after being informed of the study procedures.

Data Collection

Intervention days at each site were scheduled according to a predefined calendar. Two trained research assistants conducted all grip strength and bioelectrical impedance analysis (BIA) measurements following standardized protocols. Nurses documented weight and height within 24 hours prior to assessment.

To determine the prevalence of probable sarcopenia as defined by the EWGSOP2 criteria, HGS was measured using two instruments: the dynamometer and the vigorimeter. Two measurements were taken per hand with each device, starting with the dominant hand. A 30-second recovery was allowed between attempts. Participants were seated upright, with shoulders adducted and neutrally rotated, elbows flexed at 90 degrees, and forearms and wrists in a neutral position.

Patients were randomly assigned to start with either the dynamometer or the vigorimeter based on a predetermined random number sequence: even numbers began with the dynamometer, and odd numbers with the vigorimeter.

The Jamar dynamometer records maximal isometric grip force in kilograms (kg), reflecting peak voluntary muscle strength via a hydraulic mechanism. In contrast, the Martin vigorimeter uses a soft rubber bulb connected to a manometer to measure grip pressure in kilopascals (kPa), capturing sustained dynamic hand and finger function. Its design facilitates use among frail individuals and those with limited joint mobility.

We applied two established sets of cut-off values to define low HGS for the dynamometer: (1) the EWGSOP2 thresholds (<27 kg for men, <16 kg for women), and (2) the SDOC cut-offs proposed by Manini et al (<35.5 kg for men, <16 kg for women).^{4,22} For the vigorimeter, we applied two sets of cut-offs derived from the Swiss DO-HEALTH population: one using stricter thresholds (<64 kPa for men aged 75 or younger, <42 kPa for women aged 75 or younger; <50 kPa for men older than 75, <34 kPa for women older than 75) and another using slightly higher thresholds (<69 kPa for men aged 75 or younger, <46 kPa for women aged 75 or younger; <55 kPa for men older than 75, <39 kPa for women older than 75).⁸

To confirm sarcopenia diagnosis, muscle mass was assessed using multifrequency BIA (Nutriguard MS, Data Input GmbH, Germany) and the fat-free mass index (FFMI) was calculated using the Geneva formula,²³ which has been specifically validated in the local older population and enables use of population-specific reference values. Measurements were performed in the supine position, consistent with local protocol. Hydration status was not specifically controlled, reflecting routine inpatient screening conditions. This limitation is addressed in the discussion.

Low muscle mass was defined according to ESPEN cut-offs: $\text{FFMI} < 17 \text{ kg/m}^2$ for men and $< 15 \text{ kg/m}^2$ for women.²⁴ By combining four different cut-offs for HGS and FFMI, four distinct diagnostic criteria for confirmed sarcopenia were established (Figure 1). Additional patient data were retrieved from electronic medical records, including age, sex, length of hospital stay, level of care (acute, rehabilitation, or long-term), height, weight, body mass index (BMI), falls during hospitalization, and mortality. Falls were documented prospectively using the hospital's adverse event reporting system and confirmed by chart.

Patients with incomplete HGS or BIA assessments due to severe frailty or behavioral symptoms were excluded from the final analysis. The reasons for missing data and total numbers excluded are reported in Figure 2.

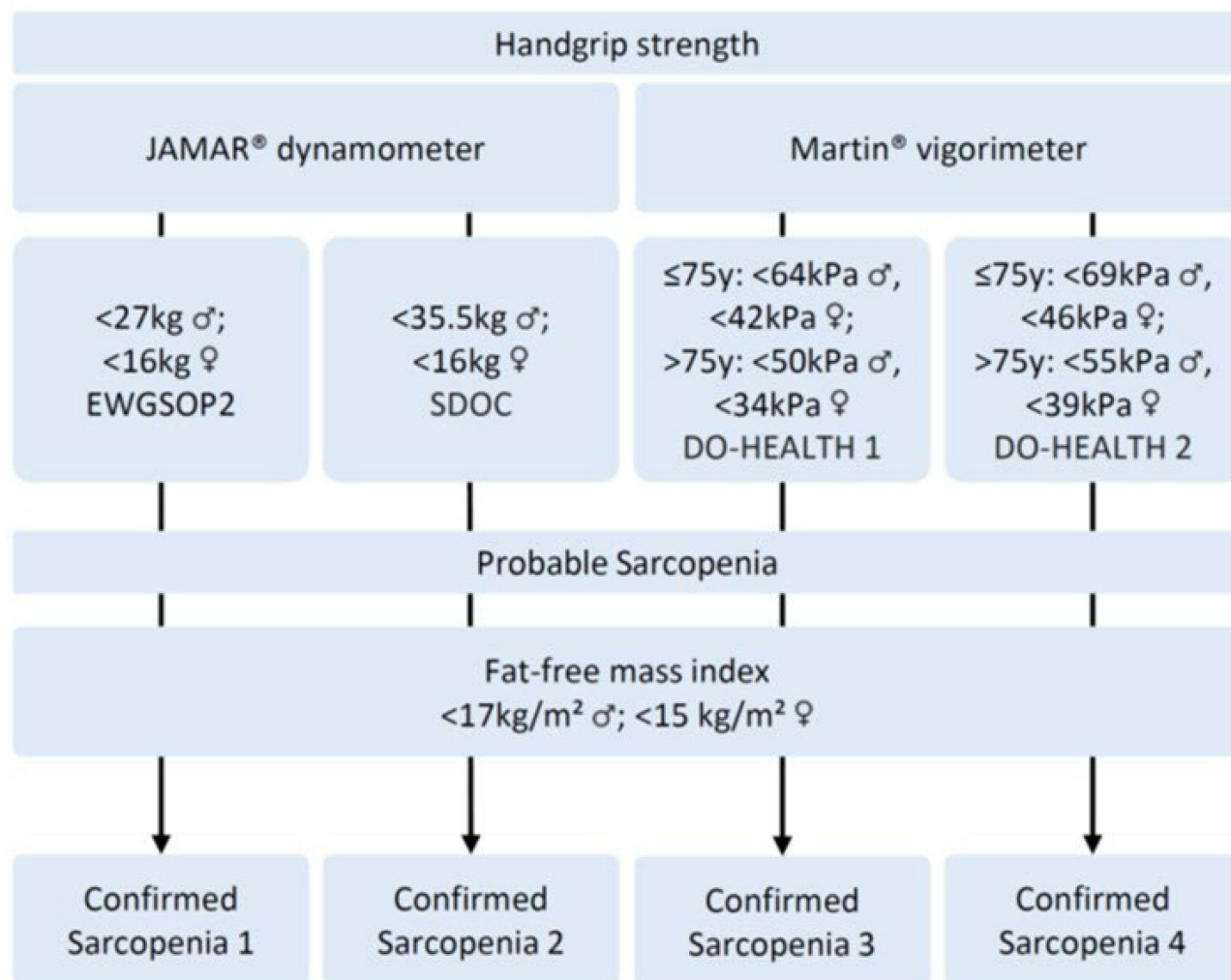


Figure 1 Diagnostic workup for sarcopenia according to different HGS methods and cut-offs.

Abbreviations: EWGSOP2, European Working Group on Sarcopenia in Older People; SDOC, sarcopenia definitions and outcomes consortium.

Statistical Analysis

Descriptive statistics were used to summarize the baseline characteristics of the study population. Continuous variables were reported as means with standard deviations (SD), and categorical variables were expressed as percentages. Differences between groups (survivors vs deceased patients) were evaluated using independent *t*-tests for continuous variables and chi-squared tests for categorical variables.

To investigate factors associated with in-hospital mortality, we performed backward stepwise logistic regression analyses. Variables included in the initial models were selected based on clinical relevance and univariate analysis results ($p < 0.20$). Handgrip strength (HGS), measured using both the dynamometer and the vigorimeter, was analyzed as continuous variables to evaluate its association with mortality. Odds ratios (ORs) with 95% confidence intervals (CI) were reported for each significant predictor. To further assess the relationship between sarcopenia and mortality, we conducted separate logistic regression models for each of the four diagnostic criteria for sarcopenia. These models also utilized backward stepwise selection, and the resulting predictors were compared across models for consistency.

Time-to-mortality analyses were performed using Cox proportional hazards regression models. Backward stepwise selection was applied to evaluate the association between HGS and mortality risk over time. Hazard ratios (HR) with 95% CIs were reported for each significant variable. To examine the impact of confirmed sarcopenia on time-to-mortality, we developed separate Cox regression models for each of the four diagnostic criteria. The proportional hazards

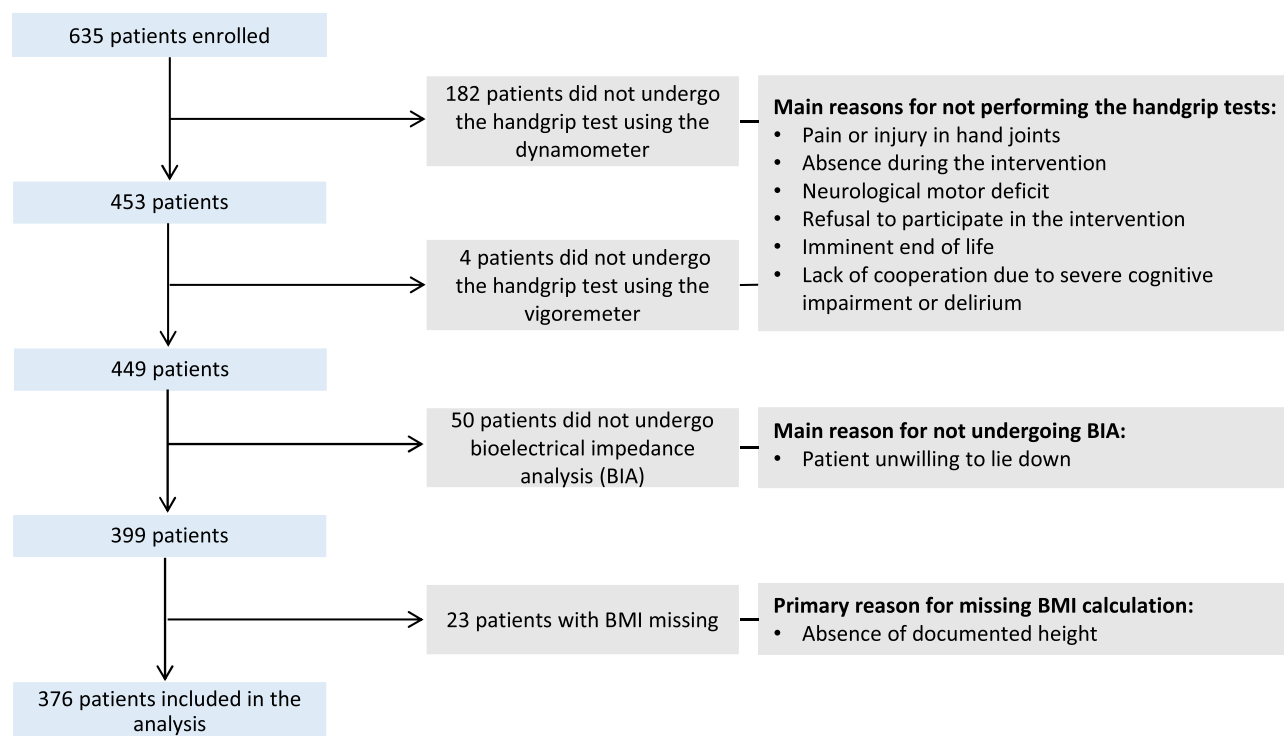


Figure 2 Flow chart of participants.

assumption was checked using Schoenfeld residuals. Kaplan-Meier survival curves were generated to visually represent time-to-mortality across confirmed sarcopenia and probable sarcopenia as defined by the different diagnostic criteria. Differences between survival curves were assessed using the Log rank test.

All analyses were conducted using Stata software, version 18.0, with a significance level set at $p < 0.05$.

Results

Patients' Characteristics and Univariate Analysis of Mortality

A total of 376 patients were included in the study, with complete HGS and BIA measurements available. Among them, 43.4% were male, and the mean age was 82.7 years (SD ± 10.9). Seventy-five patients (19.9%) died during the period of the study. Most patients were admitted to rehabilitation wards (46.8%), followed by acute care (36.7%) and long-term care units (16.5%).

Patients had a mean body weight of 64.5 kg (SD ± 14.7) and a mean BMI of 24 kg/m² (SD ± 5.1), with 10.6% classified as obese. Despite the average BMI indicating a normal weight range, the wide variability in body composition likely contributed to the observed obesity prevalence. Mean HGS values were 17.0 kg (SD ± 7.2) measured by the dynamometer and 34.3 kPa (SD ± 14.1) using the vigorimeter. The mean FFMI was 15.9 kg/m² (SD ± 2.6), and the fat mass index (FMI) averaged 8.0 kg/m² (SD ± 3.2). To provide context for sex-specific cut-offs, HGS and FFMI distributions stratified by sex are reported in [Supplementary Figure 1](#).

The prevalence of probable sarcopenia varied depending on the cut-off points applied. Using the dynamometer, probable sarcopenia was identified in 68.1% to 89.4% of patients, whereas vigorimeter-based cut-offs identified probable sarcopenia in 72.6% to 84.0% of cases. Confirmed sarcopenia prevalence ranged from 39.6% to 50.3%, based on the diagnostic criteria used.

Patients who died during hospitalization were significantly older than survivors (85.8 ± 8.9 years vs 81.9 ± 11.2 years; $p = 0.0058$). The prevalence of in-hospital falls was also higher among deceased patients (64.0% vs 40.5%; $p < 0.001$). HGS, measured with the vigorimeter, was significantly lower in patients who died (29.4 ± 12.8 kPa vs 35.5 ± 14.3 kPa; $p < 0.001$), while dynamometer-measured HGS showed no significant difference (15.7 ± 7.0 kg vs 17.4 ± 7.2 kg; $p = 0.0730$).

Although this difference was not statistically significant, the trend may be clinically relevant and consistent with findings from survival analyses.

Probable sarcopenia was more frequent among deceased patients when applying the SDOC cut-offs for dynamometer measurements (97.3% vs 87.4%; $p = 0.0123$) and the DO-HEALTH1 cut-offs for vigorimeter measurements (82.7% vs 70.1%; $p = 0.0290$). No significant differences were observed using the EWGSOP2 dynamometer cut-offs or the DO-HEALTH2 vigorimeter thresholds.

Confirmed sarcopenia was significantly more prevalent among deceased patients across all four diagnostic criteria in univariate analysis. The highest prevalence in deceased patients was observed with criterion 3 (64.0% vs 46.8%; $p = 0.0078$). Table 1 summarizes the baseline characteristics and group comparisons.

Table 1 Characteristics of the Study Population

Characteristics	Mortality		Total	p value
	No = 301	Yes = 75		
Age, y, mean (SD)	81.9 (11.2)	85.8 (8.9)	82.7 (10.9)	0.0058
Male sex, n (%)	123 (40.9%)	40 (53.3%)	163 (43.4%)	0.0512
Length of stay, d, mean (SD)	64.8 (103.7)	59.1 (76.3)	63.7 (98.9)	0.6619
Level of care, n (%)				
Acute	103 (34.2%)	35 (46.7%)	138 (36.7%)	0.2475
Rehabilitation	146 (48.5%)	30 (40.0%)	176 (46.8%)	
Long-term	52 (17.3%)	10 (13.3%)	62 (16.5%)	
Height, kg, mean (SD)	163.8 (9.2)	164.5 (10.3)	163.9 (9.5)	0.5603
Weight, cm, mean (SD)	65.1 (14.9)	62.3 (13.9)	64.6 (14.7)	0.1353
BMI, kg/m ² , mean (SD)	24.2 (5.0)	23.0 (4.7)	24.0 (5.0)	0.0518
BMI, n (%)				
<18.5	33 (11.0%)	15 (20.0%)	48 (12.8%)	0.1450
18.5–24.9	145 (48.2%)	35 (46.7%)	180 (47.9%)	
25–29.9	88 (29.2%)	20 (26.7%)	108 (28.7%)	
≥ 30	35 (11.6%)	5 (6.7%)	40 (10.6%)	
Fall during hospitalisation, n (%)	122 (40.5%)	48 (64.0%)	170 (45.2%)	<0.0010
HGS, dynamometer Kg, mean (SD)	17.4 (7.2)	15.7 (7.0)	17.0 (7.2)	0.0730
HGS, vigorimeter kPa, mean (SD)	35.5 (14.3)	29.4 (12.8)	34.3 (14.2)	<0.0010
Dynamometer, EWGSOP2 cut off, n (%)	200 (66.4%)	56 (74.7%)	256 (68.1%)	0.1717
Dynamometer, SDOC cut off, n (%)	263 (87.4%)	73 (97.3%)	336 (89.4%)	0.0123
Vigorimeter, DO-HEALTH 1 cut off, n (%)	211 (70.1%)	62 (82.7%)	273 (72.6%)	0.0290
Vigorimeter, DO-HEALTH 2 cut off, n (%)	249 (82.7%)	67 (89.3%)	316 (84.0%)	0.1620
FFMI, mean (SD)	16.1 (2.7)	15.5 (3.2)	15.9 (2.8)	0.1465
FMI, mean (SD)	8.2 (3.5)	7.5 (3.1)	8.0 (3.5)	0.1110

(Continued)

Table 1 (Continued).

Characteristics	Mortality		Total	p value
	No = 301	Yes = 75		
Sarcopenia_1, n (%)	110 (36.5%)	39 (52.0%)	149 (39.6%)	0.0144
Sarcopenia_2, n (%)	121 (40.2%)	42 (56.0%)	163 (43.4%)	0.0135
Sarcopenia_3, n (%)	141 (46.8%)	48 (64.0%)	189 (50.3%)	0.0078
Sarcopenia_4, n (%)	132 (43.9%)	45 (60.0%)	177 (47.1%)	0.0122

Abbreviations: BMI, body mass index; FFMI, fat-free mass index; FMI, fat mass index.

Factors Associated with Mortality

Backward stepwise logistic regression analyses identified several significant predictors of in-hospital mortality (Table 2). Higher HGS measured by the vigorimeter was independently associated with reduced in-hospital mortality (OR 0.96, 95% CI 0.93–0.98, $p = 0.001$), confirming the protective effect of stronger grip strength. In contrast, dynamometer-measured HGS was not significantly associated with mortality (OR 0.96, 95% CI 0.91–1.01, $p = 0.101$). This non-significant result does not exclude potential relevance of the dynamometer, as discussed in the Cox model results.

Table 2 Backward Stepwise Logistic Regression Analysis of Handgrip Strength and Sarcopenia Association with Mortality

Characteristics	OR	95% CI	p value	R ²
Model 1: dynamometer + vigorimeter				14%
Age	1.03	0.99–1.06	0.125	
Male sex	3.06	1.49–6.28	0.002	
Long term	0.37	0.16–0.89	0.026	
Rehabilitation	0.48	0.26–0.88	0.017	
In-hospital fall	2.59	1.45–4.64	0.001	
HGS vigorimeter	0.92	0.88–0.97	0.001	
HGS dynamometer	1.09	0.99–1.19	0.067	
FFMI	0.92	0.81–1.04	0.17	
Model 2: dynamometer				10%
Age	1.03	1.00–1.07	0.05	
Male sex	2.97	1.48–5.98	0.002	
Long term	0.36	0.15–0.85	0.02	
Rehabilitation	0.51	0.29–0.92	0.026	
In-hospital fall	2.6	1.47–4.61	0.001	
HGS dynamometer	0.96	0.91–1.01	0.101	
FFMI	0.91	0.80–1.02	0.115	

(Continued)

Table 2 (Continued).

Characteristics	OR	95% CI	p value	R ²
Model 3: vigorimeter				13%
Age	1.02	0.99–1.06	0.159	
Male sex	3.55	1.77–7.10	<0.001	
Long term	0.35	0.15–0.83	0.018	
Rehabilitation	0.49	0.27–0.89	0.019	
In-hospital fall	2.48	1.39–4.42	0.002	
HGS vigorimeter	0.96	0.93–0.98	0.001	
FFMI	0.92	0.82–1.04	0.538	
Model 1: sarcopenia 1				9%
Age	1.04	1.01–1.07	0.013	
Male sex	2.08	1.14–3.79	0.017	
Weight	0.98	0.96–1.01	0.149	
Long term	0.4	0.17–0.93	0.032	
Rehabilitation	0.52	0.29–0.92	0.026	
In-hospital fall	2.86	1.63–5.01	<0.001	
Model 2: sarcopenia 2				10%
Age	1.04	1.01–1.07	0.014	
Male sex	1.82	1.06–3.15	0.031	
Long term	0.38	0.16–0.89	0.025	
Rehabilitation	0.5	0.28–0.91	0.022	
Sarcopenia 2	1.77	1.01–3.10	0.047	
In-hospital fall	2.79	1.59–4.91	<0.001	
Model 3: sarcopenia 3				10%
Age	1.04	1.01–1.07	0.015	
Male sex	1.82	1.05–3.14	0.032	
Long term	0.38	0.16–0.88	0.025	
Rehabilitation	0.5	0.28–0.90	0.021	
Sarcopenia 3	1.68	0.97–2.93	0.064	
In-hospital fall	2.81	1.60–4.94	<0.001	
Model 4: sarcopenia 4				10%
Age	1.04	1.01–1.07	0.014	
Male sex	1.85	1.07–3.20	0.028	
Long term	0.38	0.16–0.87	0.023	

(Continued)

Table 2 (Continued).

Characteristics	OR	95% CI	p value	R ²
Rehabilitation	0.5	0.28–0.89	0.019	
Sarcopenia 4	1.76	1.01–3.07	0.048	
In-hospital fall	2.79	1.58–4.89	<0.001	

Notes: **Sarcopenia 1** = HGS EWGSOP2 (<27 kg for men and <16 kg for women) and FFMI (<17 kg/m² for men and <15 kg/m² for women). **Sarcopenia 2** = HGS SDOC (<35.5 kg for men and <16 kg for women) and FFMI (<17 kg/m² for men and <15 kg/m² for women). **Sarcopenia 3** = HGS DO-HEALTH1 (<64 kPa for men ≤75 years, <42 kPa for women ≤75 years, <50 kPa for men >75 years, <34 kPa for women >75 years) and FFMI (<17 kg/m² for men and <15 kg/m² for women). **Sarcopenia 4** = HGS DO-HEALTH2 (<69 kPa for men ≤75 years, <46 kPa for women ≤75 years, <55 kPa for men >75 years, <39 kPa for women >75 years) and FFMI (<17 kg/m² for men and <15 kg/m² for women).

Male sex emerged as a significant predictor, with men presenting more than a threefold increased risk of death (OR 3.06, 95% CI 1.49–6.28, $p = 0.002$). Additionally, falls during hospitalization were strongly associated with increased mortality (OR 2.59, 95% CI 1.45–4.64, $p = 0.001$). Both factors remained robustly significant across all models.

The type of care unit also influenced mortality risk. Hospitalization in long-term care (OR 0.37, 95% CI 0.16–0.89, $p = 0.026$) or rehabilitation units (OR 0.48, 95% CI 0.26–0.88, $p = 0.017$) was associated with lower mortality compared to acute care. This likely reflects a survivor effect and differences in illness severity at admission. The final models demonstrated an explanatory power (pseudo-R²) ranging from 10% to 14%, indicating modest predictive capacity at the individual level.

To further assess the association between sarcopenia and mortality, four separate backward stepwise logistic regression models were developed, each incorporating one of the four sarcopenia diagnostic criteria. In multivariate analysis, confirmed sarcopenia remained independently associated with increased mortality for criteria 2 (OR 1.77, 95% CI 1.01–3.10, $p = 0.047$) and 4 (OR 1.76, 95% CI 1.01–3.07, $p = 0.048$), whereas criteria 1 and 3 did not retain significance. Detailed results of all models are provided in [Table 3](#).

Table 3 Backward Stepwise Cox Proportional Hazards Regression Models of Handgrip Strength and Sarcopenia Association with Time-to-Mortality

Characteristics	HR	95% CI	p value	Adj. R ²
Model 1: dynamometer + vigorimeter				23%
Age	0.97	0.95–1.00	0.076	
Male sex	2.62	1.51–4.55	0.001	
Long term	0.3	0.15–0.61	0.001	
HGS vigorimeter	0.96	0.93–0.98	<0.001	
Model 2: dynamometer				20%
Age	0.98	0.95–1.00	0.146	
Male sex	2.88	1.55–5.35	0.001	
Long term	0.26	0.13–0.52	<0.001	
HGS dynamometer	0.92	0.88–0.97	0.001	

(Continued)

Table 3 (Continued).

Characteristics	HR	95% CI	p value	Adj. R ²
Model 3: vigorimeter				23%
Age	0.97	0.95–1.00	0.076	
Male sex	2.62	1.50–4.55	0.001	
Long term	0.3	0.15–0.61	0.001	
HGS vigorimeter	0.96	0.93–0.98	<0.001	
Model 1: sarcopenia 1				15%
Sarcopenia 1	1.52	0.95–2.43	0.077	
Male sex	1.56	0.97–2.50	0.067	
Long term	0.27	0.14–0.54	<0.001	
Model 2: sarcopenia 2				6%
Male sex	1.44	0.90–2.30	0.125	
Long term	0.27	0.14–0.53	<0.001	
Model 3: sarcopenia 3				15%
Sarcopenia 3	1.48	0.92–2.38	0.103	
Male sex	1.56	0.97–2.51	0.066	
Long term	0.28	0.14–0.55	<0.001	
Model 4: sarcopenia 4				14%
Sarcopenia 4	1.37	0.85–2.21	0.194	
Male sex	1.53	0.95–2.46	0.079	
Long term	0.27	0.14–0.54	<0.001	

Notes: **Sarcopenia 1** = HGS EWGSOP2 (<27 kg for men and <16 kg for women) and FFMI (<17 kg/m² for men and <15 kg/m² for women). **Sarcopenia 2** = HGS SDOC (<35.5 kg for men and < 16Kg for women) and FFMI (<17 kg/m² for men and <15 kg/m² for women). **Sarcopenia 3** = HGS DO-HEALTH1 (<64 kPa for men ≤75 years, <42 kPa for women ≤75 years, <50 kPa for men >75 years, <34 kPa for women >75 years) and FFMI (<17 kg/m² for men and <15 kg/m² for women). **Sarcopenia 4** = HGS DO-HEALTH2 (<69 kPa for men ≤75 years, <46 kPa for women ≤75 years, <55 kPa for men >75 years, <39 kPa for women >75 years) and FFMI (<17 kg/m² for men and <15 kg/m² for women).

Factors Associated with Time-to-Mortality

Backward stepwise Cox proportional hazards regression analysis revealed that higher muscle strength was significantly associated with prolonged survival, measured by both the dynamometer (HR 0.92, 95% CI 0.88–0.97, $p = 0.001$) and the vigorimeter (HR 0.96, 95% CI 0.93–0.98, $p < 0.001$). These results highlight the relevance of both instruments in longer-term prognostication.

Male sex remained a significant risk factor for reduced survival (HR 2.62, 95% CI 1.51–4.55, $p = 0.001$). Additionally, admission to long-term care units was associated with longer survival compared to acute care (HR 0.30, 95% CI 0.15–0.61, $p = 0.001$). The proportional hazards assumption was met for all models.

Confirmed sarcopenia criteria were not significantly associated with time-to-mortality in multivariate Cox models. Kaplan-Meier survival curves visually demonstrated time-to-mortality patterns. Significant differences in survival were observed for probable sarcopenia using DO-HEALTH1 vigorimeter cut-offs ($p = 0.04$), whereas no significant differences were detected for dynamometer cut-offs. For the four confirmed sarcopenia criteria, survival curves showed similar

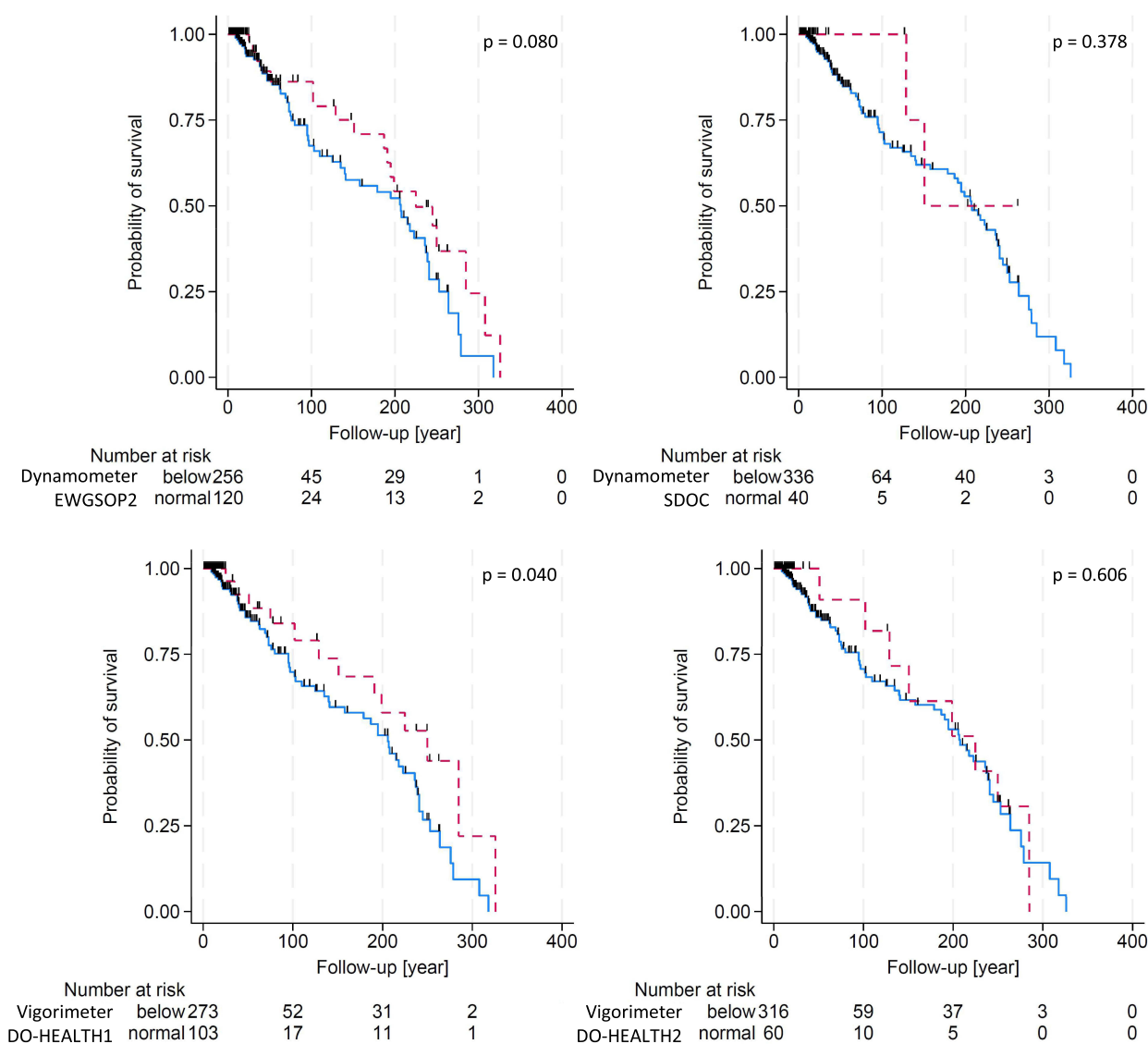


Figure 3 Kaplan-Meier curves of survival according to handgrip strength method and cut-off. P values correspond to Log rank test. Kaplan-Meier survival curves over 300 days of follow-up (X-axis: time in days). --- Below cut. — Off Normal.

mortality rates initially, with a trend toward divergence after approximately 80 days, although none reached statistical significance. Figures 3 and 4 illustrate these findings.

Discussion

In this prospective cohort study of hospitalized older adults across acute, rehabilitation, and long-term care wards, we found that lower handgrip strength (HGS), particularly when measured by the vigorimeter, was independently associated with increased mortality and shorter survival time. Furthermore, sarcopenia diagnosed according to two (criterion 2: HGS dynamometer SDOC <35.5 kg for men and <16 kg for women + FFMI <17 kg/m² for men and <15 kg/m² for women; criterion 4: HGS vigorimeter DO-HEALTH2 <69/<46 kPa for ≤75 years and <55/<39 kPa for >75 years + FFMI cut-offs) was independently associated with increased mortality but not with time-to-mortality. Other significant prognostic factors in this population were male sex and falls during hospitalization. Being admitted to rehabilitation or long-term wards were associated with reduced mortality compared to patients in acute care wards.

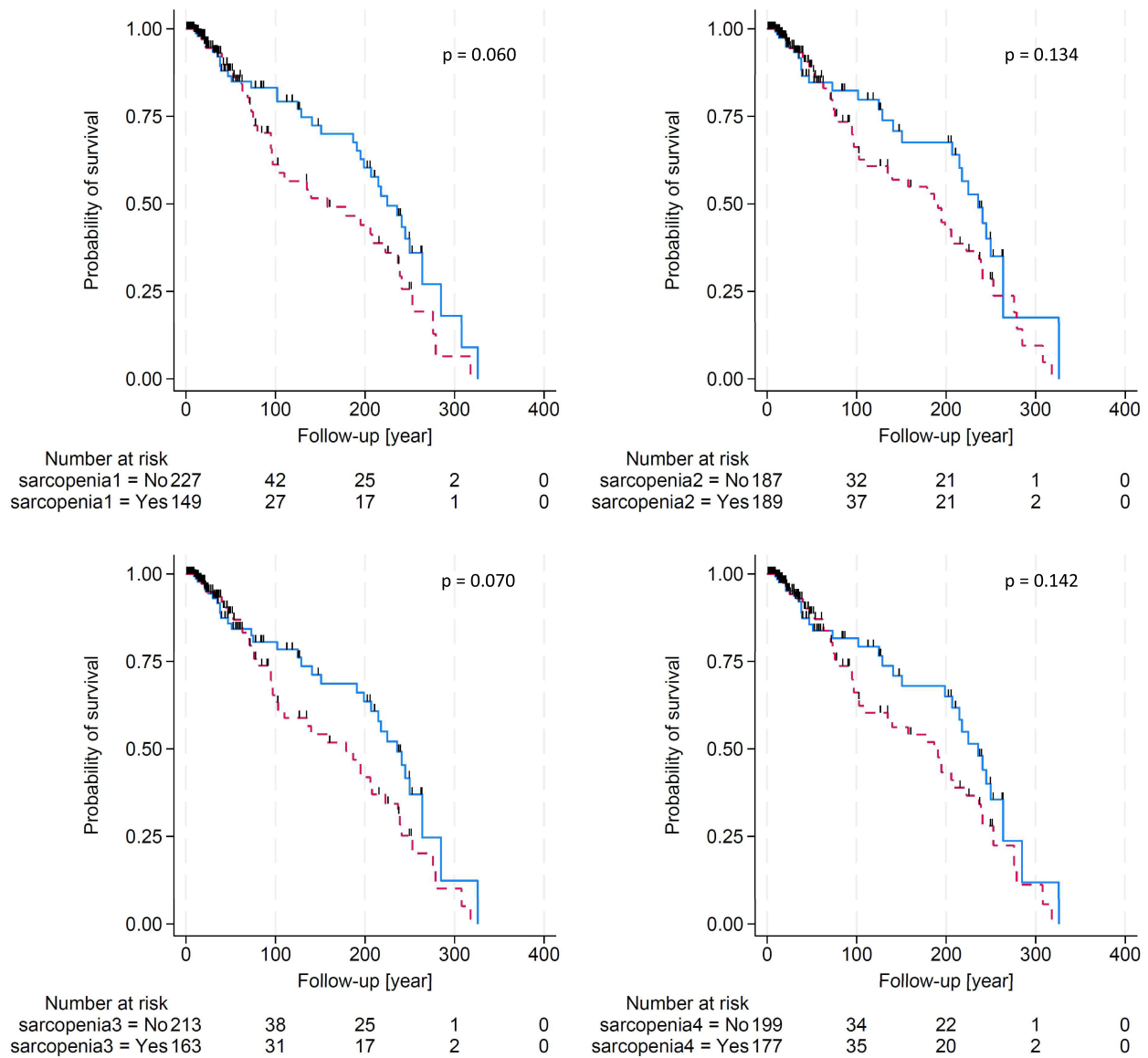


Figure 4 Kaplan-Meier curves of survival according to sarcopenia diagnoses. Sarcopenia 1 = HGS EWGSOP2 (<27 kg for men and <16 kg for women) and FFMI (<17 kg/m² for men and <15 kg/m² for women). Sarcopenia 2 = HGS SDOC (<35.5 kg for men and < 16Kg for women) and FFMI (<17 kg/m² for men and <15 kg/m² for women). Sarcopenia 3 = HGS DO-HEALTH1 (<64 kPa for men ≤75 years, <42 kPa for women ≤75 years, <50 kPa for men >75 years, <34 kPa for women >75 years) and FFMI (<17 kg/m² for men and <15 kg/m² for women). Sarcopenia 4 = HGS DO-HEALTH2 (<69 kPa for men ≤75 years, <46 kPa for women ≤75 years, <55 kPa for men >75 years, <39 kPa for women >75 years) and FFMI (<17 kg/m² for men and <15 kg/m² for women). P values correspond to Log rank test. --- Sarcopenia. — No sarcopenia.

Our findings provide novel evidence supporting the prognostic value of the vigorimeter in hospitalized older populations, underscoring its clinical utility in identifying patients at higher risk of adverse outcomes. Several biomechanical and physiological mechanisms may explain why the vigorimeter outperformed the dynamometer. Unlike the dynamometer, which captures peak isometric force through short maximal contraction—relying predominantly on fast-twitch (Type II) muscle fibers—the vigorimeter measures sustained dynamic pressure, likely engaging slow-twitch (Type I) fibers, intrinsic hand muscles, and neuromuscular coordination. These elements may deteriorate earlier during systemic deconditioning or frailty, thus increasing the sensitivity of the vigorimeter to detect high-risk individuals.

The vigorimeter’s design also accommodates older adults with arthritis, tremor, or severe weakness, who may not generate sufficient pressure on a rigid dynamometer. As such, it reduces measurement bias due to pain inhibition or mechanical limitations. Furthermore, its broader engagement of functional grip tasks may better reflect everyday motor demands, such as holding a walking aid or cutlery, than the maximal force recorded by the dynamometer. The availability

of Swiss-specific cut-offs validated in the DO-HEALTH study also enhances the clinical relevance of vigorimeter-based assessment in our population.^{8,15}

Several studies have established a clear link between HGS measured by dynamometer and all-cause mortality, including individuals with diabetes, chronic kidney disease, cancer, and cardiovascular disease.^{25–27} However, data regarding the association of HGS measured by vigorimeter with mortality is limited, with only four studies exploring this relationship.

A Norwegian study of 2529 community-dwelling older women (mean age: 72 years) demonstrated an independent association between vigorimeter-measured HGS and all-cause mortality as well as cardiovascular disease mortality over a 15-year observation period.²⁸ Another Norwegian study by Strand and colleagues, including 6850 individuals from the general population aged 50–80 years and followed for 17 years, reported significant associations of HGS with all-cause mortality, cardiovascular disease, respiratory disease, and external cause mortality, but not cancer-related mortality.²⁹ Laukannen and colleagues found comparable results in a cohort of 861 community-dwelling individuals (mean age: 69 years) in Finland, also followed for 17 years.²⁵ In the French EPIDOS study, which included 7250 non-disabled women aged 75 years or older, followed for nearly four years, vigorimeter-measured HGS was also independently associated with mortality.³⁰ Our findings build upon this evidence by demonstrating that the vigorimeter also holds prognostic value for in-hospital mortality in older patients, highlighting its broader clinical relevance across settings.

Similarly, the relationship between sarcopenia, mortality, and length of survival has been well established by several studies, predominantly in community-dwelling settings.^{31,32} The impact of sarcopenia on mortality among hospitalized patients has also been explored, with six studies focusing on older adults in internal medicine or geriatric wards. In the study by Bayraktar and colleagues, sarcopenia was identified in 14% of 200 geriatric patients (mean age: 74 years) admitted to internal medicine wards in A Turkish hospital. Patients without sarcopenia experienced lower in-hospital mortality and longer survival after discharge.³³ A Chinese study conducted in acute geriatric wards (mean age: 79 years) reported a sarcopenia prevalence of 18% and found a significant association with three-year mortality,³⁴ with these findings further confirmed in a subsequent study by the same author.³⁵ Similarly, Sipers and colleagues observed increased two-year mortality rates in 81 older sarcopenic patients according to EWGSOP criteria (mean age: 84 years) admitted to acute geriatric wards in a Dutch hospital.³⁶

The GLISTEN study, conducted in Italy, included 610 hospitalized older adults (mean age: 80 years) admitted to geriatric or internal medicine wards.³⁷ The prevalence of sarcopenia was 22.8%, and within a median follow-up time of 30 months, the study found that sarcopenia, as defined by the EWGSOP2 criteria, was significantly associated with survival rates after adjustment for confounders. So far, this was the only published study that applied the EWGSOP2 definition of sarcopenia in mortality analysis. Lastly, the CRIME study included 770 older patients (mean age: 81 years) admitted to Italian hospitals, with a sarcopenia prevalence of 28%. This was the only study to specifically differentiate between short-term (in-hospital) and long-term (1-year) mortality, showing a significant association between sarcopenia and time-to-mortality for both periods.³⁸

In contrast to prior studies reporting associations between sarcopenia and both short- and long-term mortality, our analysis revealed that while sarcopenia was independently associated with in-hospital mortality, it did not predict time-to-mortality. Several factors may account for this discrepancy. First, the high prevalence of sarcopenia in our cohort (up to 50%) may have reduced the discriminative power of sarcopenia status to predict survival duration. Second, mortality during hospitalization may be driven primarily by acute clinical factors (eg, severity of illness, complications), overshadowing sarcopenia's prognostic influence. Kaplan-Meier curves indicated similar survival patterns in the initial period, with divergence between sarcopenic and non-sarcopenic patients emerging only after approximately 80 days.

This pattern suggests that in the short-term, mortality may be driven primarily by acute clinical factors, such as the severity of the underlying illness, complications during hospitalization, or exacerbation of comorbid conditions, overshadowing sarcopenia status. Over time, however, sarcopenia likely exacerbates chronic vulnerabilities, such as impaired physical resilience, reduced functional capacity, and increased susceptibility to subsequent new health events like infections, falls, or recurrent hospitalizations. These cumulative effects may explain the delayed divergence in survival duration, where sarcopenia exerts a stronger prognostic role on longer-term outcomes.

Interestingly, admission to long-term or rehabilitation units was associated with lower mortality, which may reflect a survivor effect. Patients must first be stabilized before transfer to these units, and therapeutic goals are typically better defined, potentially limiting exposure to invasive procedures and hospital-acquired complications.

The higher mortality observed among patients admitted to acute care wards aligns with the expected consequences of higher illness severity and acute clinical deterioration. However, in older adults, prognosis is not determined by acute pathology alone. It increasingly reflects the interaction between external stressors and the individual's intrinsic capacity, a multidimensional construct defined as the composite of physical, cognitive, psychological, sensory, and vitality domains that sustain functional resilience.³⁹ In this context, handgrip strength may serve as a pragmatic proxy for intrinsic capacity, integrating musculoskeletal performance, neuromuscular coordination, and nutritional status. While acute events trigger hospitalization, a patient's ability to respond to stress is shaped by this underlying reserve. Our findings thus support the notion that HGS, particularly when measured with the vigorimeter, captures more than sarcopenia: it reflects broader biological robustness. Importantly, the prognostic value of handgrip strength in our study was most evident in acute care settings, where timely risk stratification is critical. To our knowledge, this is the first study to demonstrate that vigorimeter-assessed handgrip strength is independently associated with in-hospital mortality among acutely hospitalized older adults, reinforcing its potential role in frontline geriatric risk assessment.

Moreover, the Cox proportional hazard model assumes a constant effect of sarcopenia over the entire follow-up period, which may not adequately capture its delayed impact. This limitation could also explain the non-significant results observed in our time-to-mortality analysis. By contrast, logistic regression models are more suitable for detecting cumulative effects, aligning with the observed association between sarcopenia and overall mortality.

Male sex emerged as a robust predictor of in-hospital mortality, consistent with prior literature.⁴⁰ Older men tend to have greater comorbidity burden, reduced physiological reserve, and poorer outcomes in response to acute illness. This phenomenon is often referred to as the male–frailty paradox, where frail men have higher mortality than equally frail women. The higher prevalence of risk factors such as cardiovascular disease, smoking, or delayed healthcare use may also contribute to these sex-based differences.⁴¹

Falls during hospitalization were also strongly associated with mortality. Falls may represent both baseline frailty and acute deterioration, and they often initiate a cascade of complications including functional decline, immobility, trauma, and delirium—all of which increase mortality risk. As such, falls may act as a sentinel marker of decompensation, underscoring the need for early multidisciplinary interventions.

This study has several limitations. First, the observational design precludes causal inferences. Second, the study was conducted at a single center, potentially limiting generalizability to other healthcare settings or populations. Third, the high prevalence of sarcopenia in our cohort may have introduced ceiling effects, reducing prognostic differentiation. Fourth, the study lacked adjustment for important potential confounders such as nutritional intake, physical activity, and micronutrient status, which were not systematically collected but are known to influence sarcopenia and mortality. Fifth, specific severity markers of acute illness, comorbidity indices, frailty indices, and cause-of-death data were not included in the models, which may have confounded associations. While falls were prospectively recorded and adjusted for, other geriatric syndromes or prior functional trajectories were not analyzed. Sixth, patients unable to complete HGS or BIA assessments due to severe frailty or behavioral symptoms were excluded, possibly introducing selection bias. Additionally, BIA, while practical for bedside use, lacks the precision of imaging techniques such as DXA or MRI for muscle mass assessment. Measurements were conducted in the supine position under standardized ward conditions without controlling for hydration status, potentially affecting FFMI estimates, although this reflects real-world screening practice. Lastly, although we applied Swiss-specific cut-offs for HGS, these thresholds require further validation in more diverse and international populations to support broader clinical applicability.

In conclusion, this study underscores the high burden of sarcopenia among hospitalized older adults and provides the first evidence that handgrip strength measured with the vigorimeter is independently associated with in-hospital mortality in an acute care setting. Unlike previous studies focused on long-term or community outcomes, our findings reveal that even in the context of acute illness, muscle function remains a key determinant of prognosis—particularly when assessed with tools sensitive to frailty and neuromuscular decline. While sarcopenia was associated with overall mortality, its influence on short-term survival was less pronounced, likely reflecting the dominant role of acute clinical factors during

hospitalization. These results highlight the clinical utility of the vigorimeter as a feasible, sensitive, and prognostically meaningful tool for bedside risk stratification in geriatric care. Our findings support the integration of harmonized sarcopenia screening and diagnostic methods into routine hospital workflows to identify high-risk patients early and guide individualized care planning.

Data Sharing Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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Disclosure

The authors declare that there are no competing interests or conflicts of interest regarding the publication of this paper.

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