The Association between Sarcopenia as a Comorbid Disease and Incidence of Institutionalisation and Mortality in Geriatric Rehabilitation Inpatients: REStORing health of acutely unwell adults (RESORT)

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Abstract
Introduction: Sarcopenia is associated with poor health outcomes and highly prevalent in individuals with age-related diseases. This study aimed to determine whether sarcopenia as a comorbid disease is associated with the incidence of institutionalisation and mortality in geriatric rehabilitation inpatients. Methods: REStORing health of acutely unwell adults (RESORT) includes geriatric rehabilitation patients assessed for sarcopenia (the European Working Group on Sarcopenia in Older People [EWGSOP, 2010], EWGSOP2 [2018], and the Asian Working Group for Sarcopenia [AWGS 2019]), multimorbidity, disease severity, and specific diseases (Charlson Comorbidity Index and Cumulative Illness Rating Scale) at admission. The incidence of institutionalisation and mortality was recorded 3 months after discharge. Logistic regressions were adjusted for age and sex with “low morbidity and no sarcopenia” as the reference group. Results: In 549 included patients (median age was 82.2 [77.4–87.7] years, 58.3% female), sarcopenia prevalence was 37.9, 18.6, and 26.1% according to EWGSOP, EWGSOP2, and AWGS 2019, respectively. Sarcopenia as a comorbid disease with high multimorbidity, dementia, diabetes mellitus, and renal impairment had higher odds of institutionalisation incidence. Sarcopenia as a comorbid disease with high multimorbidity, high disease severity, chronic obstructive pulmonary disease, osteoporosis, and renal impairment had higher odds of mortality. Conclusion: Sarcopenia as a comorbid disease is associated with a higher incidence of institutionalisation and mortality in geriatric rehabilitation inpatients. This highlights the need for in-hospital sarcopenia diagnostics and interventions.

Introduction
Sarcopenia is a disease characterised by low skeletal muscle mass (SMM), muscle strength, and physical performance [1]. The prevalence of sarcopenia is 15% in healthy older adults, 34% in geriatric outpatients [2], and...
even higher amongst hospitalised patients admitted to acute (40%) [3]. Sarcopenia is associated with poor health outcomes such as falls, fractures [4], institutionalisation [5], and mortality [6].

A recent meta-analysis showed a higher prevalence of sarcopenia amongst individuals diagnosed with cardiovascular disease (CVD), dementia, diabetes mellitus (DM), and respiratory disease [7]. Multimorbidity is the coexistence of 2 or more diseases, and comorbidity is the coexistence of 1 or more diseases with respect to an index disease [8]. Geriatric rehabilitation inpatients very often suffer from multimorbidity [9], which is associated with institutionalisation and mortality [10]. However, there is a paucity of knowledge if sarcopenia as a comorbid disease worsens these health outcomes. The aim of this study was to determine if sarcopenia as a comorbid disease is associated with the incidence of institutionalisation and mortality in geriatric rehabilitation inpatients.

Materials and Methods

Study Design and Patients

RESoRING health of acutely unwell adults (RESORT) is a longitudinal, observational, prospective inception cohort. Patients were recruited from geriatric rehabilitation wards (Royal Melbourne Hospital, Melbourne, Australia). The comprehensive geriatric assessment [11] was performed on all patients upon admission and discharge. The comprehensive geriatric assessment assesses a patient’s functional, psychological, and medical status to establish an effective treatment plan. Follow-up phone calls were performed at 3 months post-discharge.

Wave 1 data were used for the present analysis, comprising of patients admitted from October 16, 2017 and discharged by August 31, 2018. Patients were excluded if they were palliative at admission or had no capacity to consent and no nominated proxy. Of the 995 patients admitted, 152 patients were excluded, and 150 patients refused consent. Of the remaining 693, sarcopenia diagnosis was possible in 550 patients; online suppl. Table 1 (see www.karger.com/doi/10.1159/000517461 for all online suppl. material) shows the data availability for sarcopenia diagnosis. Mortality data were available for all patients and institutionalisation for 464 patients.

Patient Characteristics

Age, sex, and the length of stay were collected from the patients’ medical records. Each patient’s living status was collected via a patient survey, completed at admission to geriatric rehabilitation. Cognitive impairment was assessed by physicians and defined as being present if it was endorsed on either the Charlson Comorbidity Index (CCI) [12] or Cumulative Illness Rating Scale – geriatric version (CIRS-G) [13]; dementia or mild cognitive impairment/ minor neurocognitive disorder was listed in the discharge summary as a diagnosis; or in the presence of any of a standardised Mini-Mental State Examination (sMMSE) [14] score <24 points, a Montreal Cognitive Assessment (MoCA) [15] score <26 points, or a Rowland Universal Dementia Assessment Scale (RUDAS) [16] score <23 points. Nurses completed the malnutrition screening tool [17] with each patient and activities of daily living were assessed by occupational therapists using the Katz activities of daily living index [18], both completed at admission to geriatric rehabilitation.

Morbidity

Physicians captured the medical history and completed the CCI and the CIRS-G. The CCI is a comorbidity index including 19 diseases with a total score ranging from 0 to 37. High multimorbidity was defined as a CCI score ≥3 points, based on the median score of the cohort. The CIRS-G is a rating scale, where 14 organ systems are assigned an integer between 0 (no severity) and 4 (high severity) based on the most severe condition affecting the organ system, leading to a final total score ranging from 0 to 56. The severity index was calculated as total score divided by number of affected systems and provides an estimation of severity of bodily dysfunction. High disease severity was defined as a CIRS-G severity index ≥1.91 (indicating moderate to severe severity), based on the mean for the cohort.

Specific diseases included were CVD (myocardial infarction, heart failure, hypertension, transient ischaemic attack, ischaemic stroke, and haemorrhagic stroke), dementia (Alzheimer’s dementia, mixed dementia, Lewy body dementia, Parkinson’s dementia, and vascular dementia), DM (types 1 and 2), chronic obstructive pulmonary disease (COPD), osteoporosis, and renal impairment (acute and chronic renal impairment, and renal calculi). These diseases were chosen as they are highly prevalent in the older populations [19] and are amongst the top ten leading causes of global deaths [20].

Sarcopenia Measures

Muscle mass, muscle strength, and physical performance were measured at admission to geriatric rehabilitation. Direct segmental multifrequency bioelectrical impedance analysis ([DSM-BIA], In-Body S10, Biospace Co., Ltd, Seoul, Korea) was used by trained nursing staff to assess body composition. DSM-BIA measurements were not performed on patients with cardiac pacemakers, limb amputations, or bandages or plasters which interfered with electrode placement and could not be removed. Muscle mass was expressed as SMM (kg) and appendicular lean mass (ALM, kg). DSM-BIA has been validated for whole and segmental body composition measurements against dual energy X-ray absorptiometry and is more practical than the latter in this population [21]. SMI was calculated as SMM/height² (kg/m²) and ALM/height² was calculated as ALM/height² (kg/m²). Height was determined by standing height or if a patient was unable to stand, knee height was used to approximate standing height, as calculated by the Longitudinal Aging Study Amsterdam (LASA) formulae [22]: height (cm) = 74.48 – (0.15 × age) + (2.03 × knee height [cm]) for males and height (cm) = 68.74 – (0.16 × age) + (2.07 × knee height [cm]) for females.

Handgrip strength (HGS) was measured by physiotherapists using a hydraulic handheld dynamometer (JAMAR, Sammons Preston, Inc. Bolingbrook, IL, USA). Patients were asked to squeeze maximally 3 times for each hand [23], alternating with each measure, in a seated position with the elbow bent at a 90° angle, adjacent to the body and unsupported. If a patient was unable to complete the test seated, they completed it in a supine position. Patients
were encouraged to maintain the correct testing posture and to exert a maximal force. The maximal value (in kg) was used for analyses.

The short physical performance battery (SPPB) [24], performed by physiotherapists, comprises 3 individual components: balance tests with eyes open, a 4-m walk test, and a timed chair stand test (CST). Each component has a maximum score of 4, leading to a maximum total SPPB score of 12. Measuring gait speed, patients were instructed to walk at their usual pace, and the test was performed twice, where the fastest time was used to calculate gait speed (m/s). For the CST, patients first performed a pretest to assess if they were able to stand without using their arms. If they were able, the 5-time timed CST was performed and measured in seconds.

Diagnostic Criteria of Sarcopenia

Three definitions of sarcopenia were applied at admission to geriatric rehabilitation.

1. The European Working Group on Sarcopenia in Older People 2010 (EWGSOP) [1] defines sarcopenia as low muscle mass and low muscle strength or low physical performance to define sarcopenia. Cut-off values used were SMI ≤10.75 kg/m² and ≤6.75 kg/m², HGS <30 kg and <20 kg (for males and females, respectively), and gait speed ≤0.8 m/s. If gait speed was not expressed as meter per second (but expressed as an SPPB sub-score out of 4), total SPPB was used with a cut-off of ≤8 points.

2. The EWGSOP 2018 (EWGSOP2) [25] defines sarcopenia as low muscle mass and low muscle strength. Cut-off values used were ALM/height² ≤7.0 kg/m² and ≤5.5 kg/m² and HGS <27 kg and <16 kg (for males and females, respectively). If HGS was unavailable, the CST was used with a cut-off of >15 s.

3. The Asian Working Group for Sarcopenia 2019 (AWGS 2019) [26] defines sarcopenia as low muscle mass and at least 1 of low muscle strength or low physical performance. Cut-off values used were ALM/height² ≤7.0 kg/m² and ≤5.7 kg/m², HGS <28 kg and <18 kg (for males and females, respectively), and gait speed ≤1.0 m/s. If gait speed was not expressed as m/s (but expressed as an SPPB sub-score out of 4), either CST or a total SPPB score was used with cut-off values of ≥12 s and ≤9, respectively.

If patients had 2 or more of the sarcopenia measures missing to complete the EWGSOP and AWGS 2019 diagnoses, sarcopenia could not be diagnosed. If either muscle strength or physical performance was missing, sarcopenia diagnosis was possible if the available component was abnormal. If patients had missing muscle strength to complete the EWGSOP2 diagnoses, sarcopenia could not be diagnosed. If muscle mass was missing to complete all 3 definitions’ diagnoses and the available components were normal, patients could be classified as not having sarcopenia.

Institutionalisation and Mortality

The incidence of institutionalisation was defined as a new admission to a residential aged care facility within 3 months of discharge from geriatric rehabilitation. These data were collected by researchers from a 3-month follow-up phone call with either the patient or carer. Three-month mortality information was received from the Australian births, deaths, and marriages registry on 24 July, 2020, as well as patient medical records.

### Statistical Analyses

Normally distributed data were presented as mean ± standard deviation, and nonnormally distributed data were presented as median (interquartile range). The cohort was grouped into 4 categories per analysis: low morbidity and no sarcopenia, low morbidity and sarcopenia, high morbidity and no sarcopenia, and high morbidity and sarcopenia, where the former most group was the reference group. Logistic regression models were used to analyse the association of sarcopenia as a comorbid disease with the incidence of institutionalisation and mortality, adjusted for age and sex. Interaction effects of the 4 groups with age and sex were tested to determine if stratification for these variables was required. If any group had insufficient numbers (n < 5), analyses were not reported. Backward stepwise binomial logistic regression was also used.

### Table 1. Patient characteristics at admission to geriatric rehabilitation

|                     | N     | Total (N = 549) |
|---------------------|-------|----------------|
| Age, years, median [IQR] | 549   | 82.2 (77.4–87.7) |
| Female              | 549   | 320 (58.3)      |
| Institutionalised at admission | 549   | 19 (3.5)        |
| LOS, days, median [IQR] | 549   | 19 (13–29)      |
| Cognitive impairment | 549   | 344 (62.7)      |
| MST (points), median [IQR] | 543   | 1 (0–2)         |
| ADL (points), median [IQR] | 533   | 2 (1–3)         |
| Morbidity           |       |                |
| CCI score (points), median [IQR] | 549   | 2 (1–4)         |
| High multimorbidity  | 549   | 253 (46.1)      |
| CIRS-G total score (points), mean ± SD | 549 | 11.6±4.62       |
| CIRS-G severity index, mean ± SD | 549 | 1.91±0.43       |
| High disease severity | 549   | 280 (51.0)      |
| CVD                 | 549   | 464 (84.5)      |
| COPD                | 549   | 97 (17.7)       |
| Dementia            | 549   | 140 (25.5)      |
| DM                  | 549   | 198 (36.1)      |
| Osteoporosis        | 549   | 169 (30.8)      |
| Renal impairment    | 549   | 200 (36.4)      |
| Sarcopenia prevalence |      |                |
| EWGSOP              | 507   | 192 (37.9)      |
| EWGSOP2             | 544   | 101 (18.6)      |
| AWGS 2019           | 501   | 131 (26.1)      |
| Follow-up measures  |       |                |
| Incidence of institutionalisation | 463 | 120 (25.9)  |
| Mortality           | 549   | 53 (9.7)        |
to analyse the association between sarcopenia, high multimorbidity, and high disease severity and the incidence of institutionalisation and mortality. Odds ratios (ORs) and 95% confidence intervals (CIs) were reported, and \( p \) values <0.05 were considered significant. All statistical analyses were performed using the Statistical Package for the Social Sciences (IBM SPSS Advanced Statistics 27.0, Armonk, NY, USA: IBM Corp.).

### Results

Table 1 shows the median age was 82.2 (77.4–87.7) years, 58.3% of patients were female, and the median length of stay in geriatric rehabilitation was 19 (13–29) days. The prevalence of high multimorbidity was 46.1 and 51.0% for high disease severity. The prevalence of specific diseases was 84.5% CVD, 17.7% COPD, 25.5% dementia, 36.1% DM, 30.8% osteoporosis, and 36.4% renal impairment. The prevalence of sarcopenia was 37.9%, 18.6%, and 26.1% according to EWGSOP, EWGSOP2, and AWGS 2019, respectively. Online suppl. Table 2 shows the sarcopenia measures for geriatric rehabilitation inpatients at admission. The median SMI and ALM/height\(^2\) scores, respectively, were 8.83 (7.92–9.75) kg/m\(^2\) and 7.10 (6.19–8.13) kg/m\(^2\). The median HGS was 17 (12–22) kg, and the median scores for gait speed, CST, and total SPPB, respectively, were 0.42 (0.29–0.57) m/s, 21.4 (16.9–29.6) s, and 1 (0–4) points. For all measures, except CST, males had higher medians than females. Within 3
months of discharge, the incidence of institutionalisation was 25.9%, and 9.7% died either in hospital or within 3 months of discharge (Table 1). Online suppl. Tables 3 and 4 show the incidence of institutionalisation and mortality, respectively, dependent on morbidity and sarcopenia definition.

Multimorbidity

Patients with high multimorbidity and sarcopenia (EWGSOP2: OR = 2.80, 95% CI = 1.26–6.23) and patients with low multimorbidity and sarcopenia (EWGSOP2: OR = 2.69, 95% CI = 1.37–5.28; AWGS 2019: OR = 2.08, 95% CI = 1.10–3.95) had higher odds of institutionalisation than patients with low multimorbidity and no sarcopenia. No association was found for patients with high multimorbidity and no sarcopenia on institutionalisation (shown in Fig. 1a; online suppl. Table 5).

Patients with high multimorbidity and sarcopenia (EWGSOP: OR = 6.61, 95% CI = 1.93–22.7; EWGSOP2: OR = 5.75, 95% CI = 2.25–14.7; AWGS 2019: OR = 4.02, 95% CI = 1.68–9.61), patients with high multimorbidity and no sarcopenia (EWGSOP: OR = 3.44, 95% CI = 1.38–8.58; EWGSOP2: OR = 2.10, 95% CI = 1.01–4.38), and patients with low multimorbidity and sarcopenia (EWGSOP: OR = 6.04, 95% CI = 1.86–19.6; EWGSOP2: OR = 3.19, 95% CI = 1.26–8.11) had higher odds of mortality than patients with low multimorbidity and no sarcopenia (shown in Fig. 1b; online suppl. Table 5).

Fig. 2. Association between disease severity and sarcopenia and the incidence of institutionalisation (a) and mortality within 3 months post-discharge from geriatric rehabilitation (b), adjusted for age and sex with low disease severity/no sarcopenia as the reference group. EWGSOP, European Working Group on Sarcopenia in Older People; AWGS, Asian Working Group for Sarcopenia; CI, confidence interval.
Patients with low disease severity and sarcopenia (EWGSOP2: OR = 3.22, 95% CI = 1.57–6.60; AWGS 2019: OR = 2.71, 95% CI = 1.38–5.32) had higher odds of institutionalisation than patients with low disease severity and no sarcopenia. No association was found for patients with high disease severity and sarcopenia and patients with high disease severity and no sarcopenia on institutionalisation (shown in Fig. 2a; online suppl. Table 6).

**Disease Severity**

Patients with low disease severity and sarcopenia (EWGSOP2: OR = 3.22, 95% CI = 1.57–6.60; AWGS 2019: OR = 2.71, 95% CI = 1.38–5.32) had higher odds of institutionalisation than patients with low disease severity and no sarcopenia. No association was found for patients with high disease severity and sarcopenia and patients with high disease severity and no sarcopenia on institutionalisation (shown in Fig. 2a; online suppl. Table 6).

Patients with high disease severity and sarcopenia (EWGSOP: OR = 6.56, 95% CI = 1.94–22.2; EWGSOP2: OR = 4.33, 95% CI = 1.47–12.8; AWGS 2019: OR = 3.35,
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Patients with high disease severity and no sarcopenia (EWGSOP: OR = 3.06, 95% CI = 1.22–7.70; EWGSOP2: OR = 3.66, 95% CI = 1.61–8.33; AWGS 2019: OR = 3.41, 95% CI = 1.47–7.91), and patients with low disease severity and sarcopenia (EWGSOP: OR = 5.61, 95% CI = 1.70–18.5; EWGSOP2: OR = 7.89, 95% CI = 3.01–20.7; AWGS 2019: OR = 5.56, 95% CI = 2.07–13.9) had higher odds of mortality than patients with low disease severity and no sarcopenia (shown in Fig. 2b; online suppl. Table 6).

Specific Diseases
- Patients with dementia and sarcopenia (EWGSOP: OR = 4.53, 95% CI = 1.79–11.5; EWGSOP2: OR = 5.90, 95% CI = 2.69–13.0; AWGS 2019: OR = 4.24, 95% CI = 2.07–8.66), and patients with renal impairment and sarcopenia (EWGSOP2: OR = 2.42, 95% CI = 1.02–5.70), and patients with CVD and sarcopenia (EWGSOP: OR = 4.05, 95% CI = 1.79–9.12), had higher odds of mortality compared to patients without these diseases and without sarcopenia. Patients with dementia and without sarcopenia (EWGSOP: OR = 3.06, 95% CI = 1.22–7.70; EWGSOP2: OR = 3.66, 95% CI = 1.61–8.33; AWGS 2019: OR = 3.41, 95% CI = 1.47–7.91) had higher odds of mortality compared to patients without these diseases and without sarcopenia.

Fig. 4. Association between CVD (a), COPD (b), dementia (c), DM (d), osteoporosis (e), and renal impairment and sarcopenia (f) with mortality 3 months post-discharge from geriatric rehabilitation, adjusted for age and sex with no disease/no sarcopenia as the reference group. CVD, cardiovascular disease; EWGSOP, European Working Group on Sarcopenia in Older People; AWGS, Asian Working Group for Sarcopenia; NA, not applicable; CI, confidence interval; COPD, chronic obstructive pulmonary disease; DM, diabetes mellitus.
nia (EWGSOP: OR = 2.71, 95% CI = 1.42–5.15; EWGSOP2: OR = 2.85, 95% CI = 1.68–4.84; AWGS 2019: OR = 3.18, 95% CI = 1.78–5.67) had higher odds of institutionalisation than patients without dementia and without sarco-

nia. Patients without COPD and with sarcopenia (EWGSOP2: OR = 2.63, 95% CI = 1.51–4.57; AWGS 2019: OR = 1.75, 95% CI = 1.05–2.94), patients without dementia and with sarcopenia (EWGSOP2: OR = 2.38, 95% CI = 1.21–4.67), patients without DM and with sarcopenia (EWGSOP2: OR = 2.44, 95% CI = 1.31–4.57), patients without osteoporosis and with sarcopenia (EWGSOP2: OR = 2.71, 95% CI = 1.46–5.04; AWGS 2019: OR = 1.93, 95% CI = 1.08–3.42), and patients without renal impairment and with sarcopenia (EWGSOP2: OR = 2.20, 95% CI = 1.15–4.20) had higher odds of institutionalisation than patients without these diseases and without sarcopenia (shown in Fig. 3; online suppl. Table 7).

Patients with COPD and sarcopenia (EWGSOP: OR = 4.10, 95% CI = 1.41–12.0; EWGSOP2: OR = 6.66, 95% CI = 2.41–18.4; AWGS 2019: OR = 4.68, 95% CI = 1.85–11.9), patients with osteoporosis and sarcopenia (EWGSOP: OR = 4.16, 95% CI = 1.48–11.7; EWGSOP2: OR = 3.21, 95% CI = 1.28–8.05; AWGS 2019: OR = 2.41, 95% CI = 1.00–5.80), and patients with renal impairment and sarcopenia (EWGSOP2: OR = 3.16, 95% CI = 1.24–8.04) had higher odds of mortality than patients without these diseases and without sarcopenia. Patients without dementia and with sarcopenia (EWGSOP: OR = 2.99, 95% CI = 1.12–8.00; EWGSOP2: OR = 4.23, 95% CI = 2.07–8.65; AWGS 2019: OR = 2.73, 95% CI = 1.35–5.52), patients without DM and with sarcopenia (EWGSOP: OR = 3.13, 95% CI = 1.16–8.44; EWGSOP2: OR = 2.43, 95% CI = 1.17–5.07), patients without osteoporosis and with sarcopenia (EWGSOP2: OR = 2.20, 95% CI = 1.01–4.81), and patients without renal impairment and with sarcopenia (EWGSOP: OR = 3.09, 95% CI = 1.10–8.70; EWGSOP2: OR = 2.37, 95% CI = 1.06–5.28) had higher odds of mortality than patients without these diseases and no sarcopenia. No association was found for patients with specific disease and without sarcopenia (shown in Fig. 4; online suppl. Table 8).

**Sarcopenia, High Multimorbidity, and High Disease Severity**

Backward stepwise logistic regressions showed that sarcopenia, irrespective of definition, had increased odds incidence of institutionalisation (EWGSOP: OR = 1.91, 95% CI = 1.23–2.96; EWGSOP2: OR = 2.87, 95% CI = 1.74–4.75; AWGS 2019: OR = 1.93, 95% CI = 1.21–3.09). High multimorbidity and high disease severity were not selected to be included in the models (Table 2).

Backward stepwise logistic regressions showed that sarcopenia, defined by EWGSOP (OR = 2.02, 95% CI = 1.13–3.62), and high multimorbidity (OR = 1.80, 95% CI = 1.00–3.24) had increased odds of mortality, but high disease severity was not selected to be included. EWGSOP2 sarcopenia (OR = 2.97, 95% CI = 1.60–5.51) and high multimorbidity (OR = 2.02, 95% CI = 1.12–3.65) had increased odds of mortality and high disease severity was selected but did not have a significant association. AWGS

| Table 2. Results of the backward stepwise logistic regression between sarcopenia, high multimorbidity, and high disease severity on the incidence of institutionalisation and mortality |
|---------------------------------|---------|----------|---------|---------|---------|----------|---------|----------|
|                                 | Incidence of institutionalisation | Mortality       |
|                                 | n     | OR       | 95% CI  | p value | n     | OR       | 95% CI  | p value  |
| EWGSOP                          |       |          |         |         |       |          |         |          |
| Sarcopenia                      | 425   | 1.91     | 1.23–2.96| 0.004   | 507   | 2.02     | 1.13–3.62| 0.017   |
| High multimorbidity             | NS    | NS       | NS      | NS      |       | 1.80     | 1.00–3.24| 0.050   |
| High disease severity           | NS    | NS       | NS      | NS      |       | NS       | NS      | NS       |
| EWGSOP2                         |       |          |         |         |       |          |         |          |
| Sarcopenia                      | 459   | 2.87     | 1.74–4.75| <0.001  | 544   | 3.01     | 1.62–5.59| 0.001   |
| High multimorbidity             | NS    | NS       | NS      | NS      |       | 1.90     | 1.05–3.44| 0.035   |
| High disease severity           | NS    | NS       | NS      | 0.59    | 0.32–1.06| 0.079   |         |          |
| AWGS 2019                       |       |          |         |         |       |          |         |          |
| Sarcopenia                      | 420   | 1.93     | 1.21–3.09| 0.006   | 501   | 2.19     | 1.20–3.99| 0.010   |
| High multimorbidity             | NS    | NS       | NS      | NS      |       | 1.90     | 1.05–3.43| 0.033   |
| High disease severity           | NS    | NS       | NS      | NS      |       | NS       | NS      | NS       |

OR, odds ratio; CI, confidence interval; EWGSOP, European Working Group on Sarcopenia in Older People; NS, not selected; AWGS, Asian Working Group for Sarcopenia.
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2019 sarcopenia (OR = 2.19, 95% CI = 1.20–3.99) and high multimorbidity (OR = 1.90, 95% CI = 1.05–3.43) had increased odds of mortality, and high disease severity was not selected (Table 2).

Discussion

Patients with high multimorbidity and sarcopenia and patients with low disease severity and sarcopenia had higher odds of incidence of institutionalisation and mortality. Patients with sarcopenia as a comorbid disease of CVD, dementia, and DM had higher odds of incidence of institutionalisation, and patients with sarcopenia as a comorbid disease of COPD, osteoporosis, and renal impairment had higher odds of mortality.

Multimorbidity

Patients with sarcopenia, independent of multimorbidity, had higher odds of incidence of institutionalisation and all patients had higher odds of mortality. Multimorbidity [10] has been associated with both institutionalisation and mortality, and sarcopenia has also been associated with institutionalisation [5]. Furthermore, both lead to negative health outcomes such as functional decline [6, 27] and frailty, which in turn contribute to institutionalisation and mortality [28]. Sarcopenia is also associated with other outcomes such as falls and fractures [4] which also contribute to the above outcomes. This may explain why patients with high multimorbidity and sarcopenia had a higher association with the incidence of institutionalisation and mortality in this study.

Disease Severity

Patients with low disease severity and sarcopenia had higher odds of incidence of institutionalisation and all patients (high disease severity with sarcopenia, high disease severity without sarcopenia, and low disease severity with sarcopenia) had higher odds of mortality. This is in contrast with the study’s hypothesis as high disease severity [29], in hospitalised older adults, is associated with institutionalisation and mortality and the 2 together were expected to have an association with both outcomes. Interestingly, high disease severity with sarcopenia was only associated with mortality. This may be because a high disease severity would lead to a patient’s death before they are institutionalised, as evidenced by the group with the highest mortality rates being the patients with high disease severity and sarcopenia (EWG-SOP2 and AWGS2).

Specific Diseases

Sarcopenia and these age-related diseases share risk factors, namely, sedentary behaviour, inflammation, and malnutrition [7, 30, 31], and therefore, a combination of sarcopenia with another disease might worsen health outcomes. This may explain why no disease without sarcopenia (except for dementia without sarcopenia) was significantly associated with either outcome.

Sarcopenia, as well as renal impairment [32], is associated with frailty, which is in turn associated with institutionalisation and mortality. It also, alongside dementia [33], is associated with loss of function, which is in turn associated with institutionalisation. Sarcopenia, as well as COPD [34] and osteoporosis [35], is associated with falls, which is in turn associated with mortality. This may explain how sarcopenia as a comorbid disease of these diseases has higher odds of poor health outcomes.

Sarcopenia Diagnostics and Interventions

Clinicians often do not consider sarcopenia diagnostics and they report the main reason for this as not having the tools for diagnosis and not feeling responsible for sarcopenia diagnosis. Interestingly, older adults are willing to partake sarcopenia interventions, at least in the community setting, despite not knowing what sarcopenia is. The additive effect of sarcopenia as a comorbid disease on institutionalisation and mortality highlights the need of treating sarcopenia during hospitalisation and post-hospitalisation with the attempt to improve patients’ outcomes.

Sarcopenia interventions include resistance exercise training and/or nutritional intervention [36]. There is a lack of knowledge in sarcopenia interventions in the geriatric rehabilitation setting, but current knowledge on the efficacy of in-hospital exercise interventions indicates that HGS and physical performance can either be maintained or improved during hospitalisation [37]. In contrast, there is more ambiguity with regards to in-hospital nutritional interventions, where a recent meta-analysis showed conflicting impacts on muscle mass, muscle strength, physical performance and sarcopenia prevalence [38]. The geriatric rehabilitation setting provides the ideal opportunity to initiate interventions as this setting often provides exercise and nutritional interventions that may be continued in the home environment. Therefore, research into the efficacy of sarcopenia interventions in geriatric rehabilitation is required.

Strengths and Limitations

The strengths of this study can be attributed to the strengths of RESORT, which is a representative sample of
all geriatric rehabilitation patients as it has very limited exclusion criteria, allowing for inclusion of most patients. Furthermore, all tests were performed by trained clinicians, ensuring the higher quality and accuracy of collected data. There is no globally accepted definition of sarcopenia [39]; therefore, 3 definitions of sarcopenia were included in this analysis. Finally, this study is the first with a large cohort to provide a prevalence of sarcopenia according to AWGS 2019. A limitation of this study is that DSM-BIA may be affected by hydration status, which affects the fat/muscle mass ratio [40].

Conclusion

Sarcopenia as a comorbid disease is associated with the incidence of institutionalisation and mortality 3 months post-discharge from geriatric rehabilitation. This highlights the need for research evaluating in-hospital diagnostics and interventions continued in the community setting.

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Statement of Ethics

Ethics approval was obtained from Melbourne Health Human Research Ethics Committee (HREC/17/MH/103), and the study was performed in accordance with the Helsinki Declaration. Patients were included if they gave written informed consent, or if a nominated proxy gave written informed consent in case the patient had no capacity to consent for themself.

Conflict of Interest Statement

Jacob Pacifico, Esme M. Reijnierse, Wen Kwang Lim, and Andrea B. Maier declare that they have no conflicts of interest.

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Author Contributions

Jacob Pacifico: study design, data analysis, and manuscript writing. Esme M. Reijnierse, Wen Kwang Lim, and Andrea B. Maier: supervision, manuscript review, and manuscript editing.
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