Original Research

**Title:**

Sarcopenia and its components suppress the improvement of depression symptoms in patients with stroke

**Running head:**

Sarcopenia and post-stroke depression

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Acknowledgments

Conflicts of Interest: The researchers claim no conflicts of interest.

Funding: This study received no financial support.

Author Contributions: Ryo Shiraishi; Data curation, formal analysis, Investigation, Methodology, Project administration, Resources, Supervision, Writing - Original Draft.

Shunji Araki; Resources, Writing, review, and editing. Takahiro Ogawa; Writing, review and editing, Supervision, Project administration.

Data sharing: The datasets generated and/or analyzed during the current study can be made available from the corresponding author upon reasonable request.

ORCID: https://orcid.org/0000-0002-1597-3898
Title:

Association of sarcopenia and its components with depression symptoms in older patients with stroke

Running title:

Sarcopenia and post-stroke depression
Abstract:

Background: Recent studies have reported an association between sarcopenia and depression symptoms. To date, no reports have investigated the association between sarcopenia and depression symptoms evaluated using the Geriatric Depression Screening Scale (GDS)-15 in patients with stroke. Therefore, this study aimed to investigate the association between sarcopenia and its components and the improvement of depression symptoms in patients with stroke admitted to a convalescent rehabilitation ward.

Methods: Patients with stroke aged ≥65 years admitted to a convalescent rehabilitation ward were included in the study. Participants were categorized into sarcopenia and non-sarcopenia groups based on the 2019 Asian Working Group for Sarcopenia. Here, depression symptoms were evaluated using the GDS-15, in addition to demographic characteristics. This study’s primary outcome was the GDS change from admission to discharge. Multiple regression analysis was performed to investigate the association between GDS change and sarcopenia and its components.

Results: Overall, 118 participants were included, with a mean age of 78.7±8.1, and 58 (49%) were classified in the sarcopenia group. Multiple regression analysis showed that sarcopenia (β: -0.283, 95% confidence interval [CI]: -1.140 to -0.283, p < 0.001) and handgrip strength (β: -0.317, 95% CI: -0.162 to -0.014, p = 0.021) were independently associated with GDS change.

Conclusion: Sarcopenia and handgrip strength were significantly associated with improved depression
symptoms in patients with stroke admitted to a convalescent rehabilitation ward. However, further prospective studies should investigate the association between sarcopenia and depression symptoms in patients with stroke.

**key word:** stroke; sarcopenia; depression symptoms; convalescent rehabilitation ward
Introduction

Sarcopenia in patients with stroke is an important problem. Sarcopenia is characterized by the progressive loss of muscle mass and strength attributed to age and disease \(^1\). It has been shown that 53.6% of patients with stroke in the process of recovery have sarcopenia \(^2\). In addition, sarcopenia in patients with stroke has been shown to be a factor that decreases physical function and activities of daily living (ADL) \(^2,3\). Furthermore, sarcopenia in patients with stroke has been suggested to decrease the home discharge rates and increase mortality \(^4-6\). Therefore, sarcopenia may be an important factor associated with the functional outcomes in patients with stroke.

Depression symptoms are a complication of patients with stroke, and approximately 30% of these patients experience depression symptoms \(^7\). Additionally, depression symptoms have been demonstrated to be more common in older patients with stroke \(^8\). Post-stroke depression symptoms have been reported as a factor that decreases the improvement of ADLs in patients with stroke \(^9\). Furthermore, post-stroke depression symptoms have been suggested to be associated with decreased quality of life and increased mortality in patients with stroke \(^10,11\). Therefore, addressing the improvement of depression symptoms in older patients with stroke may be considered crucial in rehabilitation.

The Geriatric Depression Screening Scale (GDS) is used to assess depression symptoms \(^12\). Additionally, the GDS-15, a shortened version of the GDS, has been developed, and its usefulness has been reported \(^13,14\).
Depression symptoms, as evaluated using the GDS-15 in patients with stroke, reportedly have negative effects on physical and mental functioning and have been identified as predictors of the functional outcomes in patients with stroke. Therefore, it is important to evaluate depressive symptoms in patients with stroke; moreover, the GDS-15 is considered a suitable screening tool to evaluate depressive symptoms. In addition, the GDS-15 is a clinically versatile and useful screening tool for the early detection of patients with stroke who have depression symptoms, since it can be assessed in a short time and is less burdensome for the examinee.

Recent studies have reported an association between sarcopenia and depression symptoms. However, these reports are targeted at older patients, and evidence in patients with stroke is lacking. To date, there have been scattered studies focusing on sarcopenia and depression symptoms separately in patients with stroke; however, no studies have investigated the association between sarcopenia and depression symptoms. As sarcopenia and depression symptoms in patients with stroke are important issues in clinical practice, clarifying this association will provide evidence for improving depression symptoms in patients with stroke and contribute to academic understanding. Therefore, this study aimed to investigate the association between sarcopenia and depression symptoms evaluated using the GDS-15 in patients with stroke.
Materials and Methods

Patients and Methods

This was a single-center retrospective cohort study including patients with stroke admitted to a convalescent rehabilitation ward between April 2020 and December 2023. The inclusion criteria were patients with stroke of first occurrence aged ≥65 years who were admitted for rehabilitation therapy. Exclusion criteria were as follows: missing data on National Institutes of Health Stroke Scale (NIHSS), Charlson Comorbidity Index (CCI), Mini Nutritional Assessment-Short Form (MNA-SF), handgrip strength, skeletal muscle mass index (SMI), and GDS score.

Data collection

Age, sex, body mass index (BMI), stroke type, stroke laterality, stroke severity (NIHSS), antidepressant medication, CCI, MNA-SF, handgrip strength, SMI, functional independence measure (FIM), days from onset to admission to rehabilitation wards, length of hospital stay, rehabilitation volume, energy intake, and protein intake were collected from medical records. Diagnoses of the stroke type and stroke laterality were made by a medical doctor on admission. Stroke severity was evaluated using the NIHSS, which ranges from 0 to 42, with higher scores indicating greater neurological severity. CCI is the most commonly used multimorbidity comorbidity index in clinical practice. In the present study, 17 disease-related
conditions were scored. The total score was defined as a minimum of 0 and a maximum of 37 points, with higher scores indicating a more severe disease. A registered physical therapist evaluated the NIHSS and CCI score within 1 week of admission. The ability to perform ADLs was assessed using the FIM scale; the FIM scores were calculated by nurses on admission and discharge. FIM is an evaluation tool that assesses the amount of assistance required by a patient to perform various activities. FIM uses a 7-point scoring scale consisting of 13 motor items and 5 cognitive items, with a minimum total score of 18 (low ADL) and a maximum score of 126 (high ADL).

Nutritional assessment

MNA-SF is widely used as a nutritional screening tool. Each patient was scored by a registered dietitian upon admission. MNA-SF is an abridged version of the MNA for older adults aged ≥65 years, and its usefulness as a simple tool for screening nutritional status has been confirmed in previous studies. It comprises six items: food intake, weight loss, mobility, physical/mental stress, neuropsychological problems, and BMI. Each item is scored on a 0–2-point or 0–3-point scale, and the total score ranges from 0 to 14. Energy and protein intakes were averaged for the week before discharge and retrospectively examined using data recorded by nurses and registered dietitians. Daily energy and protein intakes per kilogram were calculated by dividing by the patient’s current body weight.
Rehabilitation volume

The duration of the rehabilitation program, which included standing, walking, stretching, strength training, and ADL training, was approximately 60–180 min/day. Strength training included a combination of open and closed kinetic chains. In the open kinetic chain, exercises focused on single-joint movements, including strength training of the hip extensors and abductor muscles and knee flexors and extensors. The closed kinetic chain focused on multi-joint movements, such as sitting and standing, balance training, walking training, and stepping movements. These rehabilitation programs were implemented while adapting to the patient’s condition by adjusting the intensity of training.

Geriatric Depression Screening Scale-15

The GDS-15, which is an evaluation of 15 depression symptom-related questions answered with “yes” or “no” responses, was used to evaluate depression symptoms. The total GDS score ranges from a minimum of 0 to a maximum of 15, with higher scores indicating greater depressive tendencies. Additionally, the GDS-15 has been reported to be a valid tool for evaluating depression symptoms and is widely used internationally. Here, GDS change (GDS at discharge - GDS on admission) was calculated as the primary outcome measure. If it improves (becomes negative), the value is negative.
Sarcopenia definition

Sarcopenia was diagnosed in this study using handgrip strength and SMI, based on the diagnostic criteria of the Asian Working Group for Sarcopenia (AWGS) 2019. A registered physical therapist or occupational therapist measured the handgrip strength within 1 week of admission. Left and right handgrip strengths were measured using a Smedley hand dynamometer (Grip-D, Takei Kiki Kogyo, Niigata, Japan), and the maximum value was adopted. SMI was measured using bioelectrical impedance analysis. Measurements using the InBody S10 (InBody Japan, Tokyo, Japan) were performed by placing the patient in the supine position without any burden on the patient. After 15 min of rest in the supine position, the electrodes were placed on the thumbs, third fingers, and wrists of both hands for measurement. SMI was calculated by dividing the skeletal muscle mass by the square of the height. The cutoff values for sarcopenia in the AWGS 2019 are handgrip strength (male <28 kg, female <18 kg) and SMI (male <7.0 kg/m², female <5.7 kg/m²). According to this criterion, patients who met the diagnosis and the others were classified into the sarcopenia and non-sarcopenia groups, respectively.

Sample size calculation

The sample size was calculated using G*power software 3.1 ver. 3.1.9.6 (Heinrich Heine University
Düsseldorf, Germany). G*Power is a free power analysis program for the implementation of various statistical tests for performing sample size calculations. Assuming the multiple regression model with the 9 explanatory variables for which we want to estimate the standard partial regression coefficient and given an effect size of moderate ($f^2 = 0.15$) is obtained, and testing at an $\alpha$ error of 0.05 and power of 0.8, we calculated a total of 114 cases in this study. Therefore, data were collected from more than 114 participants.

Ethics Approval

This study was approved by our hospital’s Ethical Review Committee (approval number: 24-01) with regard to the handling of personal information. An opt-out procedure was used to provide all patients with the option of excluding their data from the analysis instead of providing written informed consent because of the retrospective design of the study. All experimental procedures were performed in accordance with the principles of the Declaration of Helsinki (revised October 2013). Also, this study complied with the ethical guidelines for authorship and publishing in the Annals of Geriatric Medicine and Research.

Statistical Analysis

Continuous variables were tested for normality using the Kolmogorov–Smirnov test. The t-test or Mann–
Whitney U test was used for the group comparisons of age, BMI, NIHSS score, CCI, MNA-SF, handgrip strength, FIM score, days from onset to admission to rehabilitation wards, length of hospital stay, rehabilitation volume, protein intake, energy intake, and GDS change. Fisher's exact probability test was used for the group comparisons of sex, stroke type and laterality, and antidepressant medication. The sarcopenia and non-sarcopenia groups were compared. Quantitative variables are expressed as the mean ± standard deviation and median and interquartile range for normal and non-normal distributions, respectively. Qualitative variables are expressed as frequencies.

Multiple regression analysis was performed to examine the association between GDS change and sarcopenia and between handgrip strength, which is a component of sarcopenia, and SMI. Explanatory variables were those reported to be associated with the GDS in previous studies or those considered clinically relevant. The selection of explanatory variables was adjusted based on the sample size and multicollinearity. Sarcopenia, handgrip strength, and SMI were included in Models 1, 2, and 3, respectively. Other explanatory variables were age, sex, antidepressant medication, NIHSS score on admission, GDS score on admission, FIM score on admission, length of hospital stay, and rehabilitation volume. All statistical analyses were performed using JMP 15 (SAS Institute Inc., Cary, NC, USA), with a significance level of 5%.
The study enrolled 176 patients with stroke who were admitted to a convalescent rehabilitation ward during the study period. A total of 58 patients with missing data on NIHSS score (n = 10), handgrip strength (n = 8), GDS score (n = 27), and SMI (n = 13) at admission were excluded (Fig. 1). Finally, 118 patients (58 males and 60 females) were included in the analysis (Fig. 1).

The mean age of the patients was 78.7 ± 8.1 years. In total, 58 (29 males, 29 females) and 60 (29 males, 31 females) patients were in the sarcopenia and non-sarcopenia groups, respectively. Antidepressant medications were used by 17 (1%) patients overall, 9 (2%) in the sarcopenia group and 8 (1%) in the non-sarcopenia group (Table 1).

When comparing the two groups, the patients with stroke who had sarcopenia had significantly lower MNA-SF, handgrip strength, SMI, and FIM on admission. Additionally, GDS was higher and protein intake and GDS change, FIM, and FIM gain were significantly lower at discharge (Table 2).

Table 3 shows the results of the multiple regression analysis of the three models for GDS change as an outcome. All the models included the same covariates for adjustment. In Model 1, sarcopenia ($\beta$: -0.283, 95% confidence interval [CI]: -1.140 to -0.283, $p < 0.001$, and adjusted $R^2$: 0.327) was associated with GDS change. In Model 2, handgrip strength at admission ($\beta$: -0.317, 95%CI: -0.162 to -0.014, $p = 0.021$, $R^2$: 0.296) was associated with GDS change. In Model 3, SMI at admission ($\beta$: -0.251,
95% CI: -1.130 to -0.117, p = 0.163, R²: 0.299) was not associated with GDS change. These results indicate that sarcopenia and handgrip strength at admission were associated with GDS changes. Furthermore, the variance inflation factor was <3, confirming the absence of multicollinearity.

Discussion

This retrospective cohort study investigated the association between sarcopenia and the components of sarcopenia and improvement in depression symptoms in older patients with stroke. In summary, sarcopenia was a factor negatively associated with improvement in depression symptoms in patients with stroke undergoing convalescent rehabilitation. Reduced handgrip strength, which constitutes sarcopenia, was also negatively associated with improved depression symptoms. These findings suggest that evaluating sarcopenia and handgrip strength in older patients with stroke may help improve post-stroke depression symptoms.

Sarcopenia at admission was negatively associated with improved depression symptoms in older patients with stroke. Stroke is a major disease that occurs more frequently in older adults, which may account for the high rate of age-related sarcopenia. In addition, systematic reviews and meta-analyses of post-stroke sarcopenia have reported that, in addition to aging, muscle atrophy due to paralysis and disuse also contribute to the progression of sarcopenia in patients with stroke. Previous reports have shown that...
the prevalence of sarcopenia is as high as 51.6% in patients with stroke during the recovery process. The rate of sarcopenia among older patients with stroke undergoing convalescent rehabilitation in this study was 49%, which is comparable to previous results. Previous studies on sarcopenia demonstrated a correlation between sarcopenia and depression symptoms in systematic reviews and meta-analyses. In addition, older adults with sarcopenia have been shown to have a higher prevalence of depression symptoms. Furthermore, longitudinal cohort studies have shown that sarcopenia exacerbates the risk of developing depression symptoms within one year. However, no studies have investigated the combined effects of sarcopenia and depression symptoms in patients with stroke. Therefore, it may be advisable to consider patients with stroke who have sarcopenia to have depression symptoms to monitor the worsening of symptoms over time. This is the first study to investigate the relationship between sarcopenia and depression symptoms in older patients with stroke undergoing convalescent rehabilitation. The relationship between sarcopenia and depressive symptoms is presented as a piece of evidence to better understand depressive symptoms in patients with stroke. Thus, the results suggest that it is important to evaluate sarcopenia early in older patients with stroke.

Reduced handgrip strength, a component of sarcopenia, was a factor that negatively affected the improvement of depression symptoms in patients with stroke. Studies investigating the relationship between the components of sarcopenia and depression symptoms have shown that reduced handgrip strength in older adults negatively affected the depressive symptoms. In addition, a large longitudinal
cohort study has shown that depression symptoms worsen with reduced handgrip strength. Furthermore, depression symptoms have been shown to persist over time in psychiatric patients with reduced handgrip strength. Therefore, based on these reports and the present findings, reduced handgrip strength, a component of sarcopenia, may be associated with depression symptoms. Handgrip strength, which is one of the indices that reflect physical function, is used to measure skeletal muscle strength. Handgrip strength is also used as a diagnostic factor for sarcopenia, and reduced handgrip strength is indicative of a decline in the overall physical function. Therefore, evaluating handgrip strength, which can be easily measured in clinical practice, may be useful for the early detection of depression symptoms. To date, there have been no reports investigating the association between reduced handgrip strength and depression symptoms in patients with stroke undergoing convalescent rehabilitation. The findings are the first study to clearly demonstrate that decreased handgrip strength may impair the improvement of depression symptoms in patients with stroke. Therefore, handgrip strength, a component of sarcopenia, is an important clinical factor in improving depression symptoms in patients with stroke, suggesting the importance of evaluating handgrip strength from the early stage of the disease.

Our findings may assist clinicians during the rehabilitation of patients with stroke. To date, individual evidence of sarcopenia and depression symptoms in patients with stroke has been reported. However, no studies have investigated the relationship between depression symptoms and both sarcopenia and related factors in patients with stroke; moreover, clinical findings are often unclear. This is the first study to show...
that sarcopenia and reduced handgrip strength are associated with improved depression symptoms in patients with stroke. Systematic reviews and meta-analyses have shown that exercise therapy, including resistance training and aerobic exercise, is effective in improving depression symptoms after stroke. Resistance training and aerobic exercise has been incorporated into rehabilitation programs for patients with stroke to help restore physical function and ADLs. Therefore, it is important to recommend a rehabilitation program that focuses on strengthening physical function in patients with stroke who have depression symptoms, in addition to evaluating sarcopenia and handgrip strength early in hospitalization.

This study has certain limitations. First, this was a single-center retrospective cohort study, which limits the generalizability of the results. Second, the statistical methods used did not reveal a causal relationship between sarcopenia and depression symptoms. Therefore, investigating this issue through prospective validation is necessary. Third, the GDS-15, while useful as a screening tool for depression symptoms, has certain limitations. The GDS-15 requires verbal answers to several questions, and therefore, individuals with speech impairments are not eligible for evaluation using GDS-15. As such, the patients with stroke included in this study may have been subject to selection bias, which necessitates caution in generalizing the study results to the entire population of patients with stroke. Additionally, this study was not able to assess the depression symptoms in detail. Depression symptoms are classified into unipolar disorder with depression symptoms only and bipolar disorder with manic states. Since the classification of depression symptoms may have influenced the results of this study, more detailed evaluation is warranted in the future.
Furthermore, several other tools have been reported to screen for depression symptoms. For example, the Hamilton Depression Rating Scale has been shown to be useful as a general index for evaluating depression symptoms. Therefore, a more multifaceted approach that considers other factors besides those in the GDS-15 is needed to diagnose depression symptoms in the future. Fourth, this study did not establish a baseline for the study participants. Therefore, the changes in the depression symptoms investigated in this study may have been influenced by the baseline GDS score. In the future, it is necessary to construct a study design with a strict baseline setting and examine the factors that contribute to the change in the depression symptoms.

In conclusion, sarcopenia was associated with improved depression symptoms in patients with stroke admitted to convalescent rehabilitation wards. Among the components of sarcopenia, reduced handgrip strength was associated with improved depression symptoms. Therefore, this study suggests sarcopenia and handgrip strength to be important clinical factors in the rehabilitation of physical and mental functions in patients with stroke.

Acknowledgments

We would like to acknowledge all patients who agreed to participate in this study.


42. Eng JJ, Reime B. Exercise for depressive symptoms in stroke patients: a systematic review and meta-

**Figure Legend**

**Figure 1 Flowchart of the study**

Abbreviations: NIHSS, National Institutes of Health Stroke Scale; GDS, Geriatric Depression Screening Scale; SMI, Skeletal muscle mass index
<table>
<thead>
<tr>
<th></th>
<th>Overall (n = 118)</th>
<th>Sarcopenia group (n = 58)</th>
<th>Non-sarcopenia group (n = 60)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, years</td>
<td>78.8 ± 8.1</td>
<td>79.6 ± 7.6</td>
<td>77.9 ± 8.6</td>
<td>0.204</td>
</tr>
<tr>
<td>Sex, n (%)</td>
<td></td>
<td></td>
<td></td>
<td>1.000</td>
</tr>
<tr>
<td>Male</td>
<td>58 (49)</td>
<td>29 (50)</td>
<td>29 (48)</td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>60 (51)</td>
<td>29 (50)</td>
<td>31 (52)</td>
<td></td>
</tr>
<tr>
<td>BMI, kg/m²</td>
<td>23.1 ± 3.4</td>
<td>21.9 ± 2.9</td>
<td>24.3 ± 3.5</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Stroke type, n (%)</td>
<td></td>
<td></td>
<td></td>
<td>0.269</td>
</tr>
<tr>
<td>Brain infarction</td>
<td>85 (72)</td>
<td>42 (72)</td>
<td>43 (72)</td>
<td></td>
</tr>
<tr>
<td>Brain hemorrhage</td>
<td>23 (20)</td>
<td>9 (16)</td>
<td>14 (23)</td>
<td></td>
</tr>
<tr>
<td>Subarachnoid hemorrhage</td>
<td>10 (8)</td>
<td>7 (12)</td>
<td>3 (5)</td>
<td></td>
</tr>
<tr>
<td>Stroke laterality, n (%)</td>
<td></td>
<td></td>
<td></td>
<td>0.583</td>
</tr>
<tr>
<td>Right side</td>
<td>52 (44)</td>
<td>24 (41)</td>
<td>28 (47)</td>
<td></td>
</tr>
<tr>
<td>Left side</td>
<td>66 (56)</td>
<td>34 (59)</td>
<td>32 (53)</td>
<td></td>
</tr>
<tr>
<td>Antidepressant medication, n (%)</td>
<td>17 (1)</td>
<td>9 (2)</td>
<td>8 (1)</td>
<td>0.797</td>
</tr>
</tbody>
</table>

Continuous variables are displayed as mean ± standard deviation, values are presented as medians with interquartile ranges. Abbreviations: BMI, Body mass index.
<table>
<thead>
<tr>
<th></th>
<th>Overall (n = 118)</th>
<th>Sarcopenia group (n = 58)</th>
<th>Non-sarcopenia group (n = 60)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>On admission</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CCI, points</td>
<td>1 [1–2]</td>
<td>1 [1–2]</td>
<td>1 [1–2]</td>
<td>0.442</td>
</tr>
<tr>
<td>MNA-SF, points</td>
<td>7 [6–9]</td>
<td>7 [5–8]</td>
<td>8 [6–9]</td>
<td>0.006</td>
</tr>
<tr>
<td>Handgrip strength, kg</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>24.2 ± 8.9</td>
<td>18.6 ± 6.6</td>
<td>29.6 ± 7.4</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Female</td>
<td>13.3 ± 5.4</td>
<td>11.2 ± 3.2</td>
<td>15.3 ± 6.2</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>SMI, kg/m²</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>6.4 ± 0.9</td>
<td>5.8 ± 0.7</td>
<td>7.0 ± 0.7</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Female</td>
<td>5.3 ± 0.8</td>
<td>4.8 ± 0.6</td>
<td>5.8 ± 0.6</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>FIM total, points</td>
<td>58.9 ± 17.2</td>
<td>52.7 ± 15.3</td>
<td>65.0 ± 16.9</td>
<td>0.002</td>
</tr>
<tr>
<td>Days from onset to admission to rehabilitation wards, days</td>
<td>20.1 ± 12.2</td>
<td>20.5 ± 12.3</td>
<td>19.7 ± 12.1</td>
<td>0.740</td>
</tr>
<tr>
<td><strong>At discharge</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Length of hospital stay, days</td>
<td>90.6 ± 49.3</td>
<td>95.7 ± 49.4</td>
<td>85.7 ± 49.1</td>
<td>0.276</td>
</tr>
<tr>
<td>Rehabilitation volume, min/day</td>
<td>140.7 ± 40.1</td>
<td>135.0 ± 29.7</td>
<td>146.2 ± 47.7</td>
<td>0.129</td>
</tr>
<tr>
<td>Protein intake, g/kg/day</td>
<td>1.1 ± 0.1</td>
<td>1.0 ± 0.1</td>
<td>1.1 ± 0.1</td>
<td>0.005</td>
</tr>
<tr>
<td>Energy intake, kcal/day</td>
<td>1601.0 ± 402.7</td>
<td>1584.8 ± 437.0</td>
<td>1616.6 ± 369.6</td>
<td>0.671</td>
</tr>
<tr>
<td>GDS change, point</td>
<td>-1.4 ± 2.5</td>
<td>-1.0 ± 1.6</td>
<td>-2.0 ± 3.0</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>FIM total, points</td>
<td>88.3 ± 26.3</td>
<td>78.8 ± 23.1</td>
<td>97.6 ± 26.0</td>
<td>0.004</td>
</tr>
<tr>
<td>FIM gain, points</td>
<td>29.4 ± 16.3</td>
<td>26.1 ± 14.7</td>
<td>32.5 ± 17.2</td>
<td>0.029</td>
</tr>
</tbody>
</table>

Continuous variables are displayed as mean ± standard deviation or medians with interquartile ranges. Abbreviations: NIHSS, National Institutes of Health Stroke Scale; CCI, Charlson comorbidity index; MNA-SF; Mini Nutritional Assessment−Short Form; GDS; Geriatric depression screening scale; SMI; Skeletal muscle mass index; FIM, Functional independence measure.
Table 3. Multiple regression analysis for Geriatric Depression Screening Scale change

<table>
<thead>
<tr>
<th>Factor</th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>β (95% CI)</td>
<td>p-value</td>
<td>β (95% CI)</td>
</tr>
<tr>
<td>Sarcopenia a)</td>
<td>-0.283 (-1.140 to -0.283)</td>
<td>&lt; 0.001</td>
<td>-</td>
</tr>
<tr>
<td>Handgrip strength on admission</td>
<td>-</td>
<td>-</td>
<td>-0.317 (-0.162 to -0.014)</td>
</tr>
<tr>
<td>SMI on admission</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Age</td>
<td>-0.020 (-0.060 to 0.048)</td>
<td>0.825</td>
<td>-0.091 (-0.088 to 0.032)</td>
</tr>
<tr>
<td>Sex b)</td>
<td>0.013 (-0.396 to 0.463)</td>
<td>0.878</td>
<td>0.182 (-0.113 to 1.025)</td>
</tr>
<tr>
<td>Antidepressant medication c)</td>
<td>-0.089 (-0.916 to 0.283)</td>
<td>0.2978</td>
<td>-0.104 (-0.985 to 0.241)</td>
</tr>
<tr>
<td>NIHSS on admission</td>
<td>-0.028 (-0.073 to 0.053)</td>
<td>0.752</td>
<td>-0.042 (-0.080 to 0.050)</td>
</tr>
<tr>
<td>GDS on admission</td>
<td>-0.479 (-0.399 to -0.198)</td>
<td>&lt; 0.001</td>
<td>-0.513 (-0.426 to -0.214)</td>
</tr>
<tr>
<td>FIM on admission</td>
<td>0.034 (-0.025 to 0.035)</td>
<td>0.741</td>
<td>0.037 (-0.027 to 0.038)</td>
</tr>
<tr>
<td>Length of hospital stay</td>
<td>0.104 (-0.005 to 0.015)</td>
<td>0.287</td>
<td>0.062 (-0.007 to 0.013)</td>
</tr>
<tr>
<td>Rehabilitation volume</td>
<td>-0.070 (-0.015 to 0.006)</td>
<td>0.394</td>
<td>-0.104 (-0.017 to 0.004)</td>
</tr>
</tbody>
</table>

Adjusted R squared model (R^2): Model 1 = 0.327, Model 2 = 0.296, Model 3 = 0.299. Abbreviations: CI, confidence interval; SMI, Skeletal muscle mass index; NIHSS, National Institutes of Health Stroke Scale; GDS, Geriatric Depression Screening Scale; FIM, Functional independence measure.

a) Sarcopenia: Non-sarcopenia and Sarcopenia are coded as 0 and 1, respectively.

b) Sex: Male and Female are coded as 0 and 1, respectively.

c) Antidepressant medication use and no-use are coded as 1 and 0, respectively.