Nutritional status and physical performance using handgrip and SPPB tests in hospitalized older adults

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Abbreviations:

SPPB: Short Physical Performance Battery

MNA-SF: Mini Nutritional Assessment-Short Form

CVD: Cardiovascular Disease

COPD: Chronic Obstructive Pulmonary Disease
Abstract

**Background & Aims:** Malnutrition and poor physical performance are highly prevalent within hospitalized older adults, and both have in common the loss of muscle mass. Likewise, there is growing interest in identifying markers of physical performance, other than just measuring muscle mass, that might be useful for managing malnutrition. This study aimed to (i) characterize the physical condition of hospitalized older adults in comparison to previously published reference percentile values of same age adults and (ii) to examine the association between the nutritional status and physical performance of older inpatients.

**Methods:** A total of 604 inpatients (age 84.3±6.8 years, 50.3% women) participated in this cross-sectional study. Patients were assessed for nutritional status (Mini Nutritional Assessment-Short Form (MNA-SF)) and physical performance (handgrip strength and the Short Physical Performance Battery (SPPB)).

**Results:** During hospitalization, 65.7% of the inpatients were at risk of malnutrition or malnourished. More than a half of the older inpatients were unfit (≤ P25) for handgrip strength (52.0%) and SPPB total score (86.3%) as well as for two of its subtests, gait speed (86.7%) and 5 times sit-to-stand (91.1%) tests. Patients’ nutritional status was significantly associated with better physical performance within all tests (all \( p < 0.001 \)), as their nutritional status improved so did their physical performance (all \( p \) for trend < 0.001). Hence, being at risk of malnutrition or malnourished significantly increased the likelihood for being classified as unfit according to handgrip strength (OR: 1.466, 95% CI: 1.045-2.056), SPPB total score (OR: 2.553, 95% CI: 1.592-4.094) and 4-m walking test (OR: 4.049, 95% CI: 2.469-6.640) (all \( p < 0.05 \)), and as frail (OR: 4.675, 95% CI: 2.812-7.772) according to the SPPB frailty threshold (\( p < 0.001 \)).
**Conclusions:** this study reinforces the use of handgrip strength and SPPB, as well as its subtests (gait speed and 5 times sit-to-stand tests), in hospitalized older adults as alternative measures of muscle mass for malnutrition management. Hence, it seems that risk of malnutrition or malnutrition assessed by MNA-SF might help to predict poor physical performance in older inpatients.

**Key words:** older adults, inpatient, malnutrition, handgrip, physical performance, muscle strength.
**Introduction**

Malnutrition is highly prevalent in older adults with greater numbers in hospitalized patients as well as in nursing homes [1]. Malnutrition occurs along with the aging process *per se* as well as with a background of chronic co-morbidities and/or acute conditions [2]. Malnourished older adults are at higher risk of fracture [3] and mortality [4, 5], and the recovery from any disease, trauma and/or surgery intervention is delayed [5]. In addition, malnutrition in older adults is associated with longer stays in hospital and higher readmissions rates with the subsequent economic burden for health care systems [4].

One of the most critical outcomes of malnutrition is the loss of muscle mass [6], which is exacerbated within hospitalized older patients due to inactivity [7] and the associated acute and/or chronic conditions [8]. Most of the techniques to measure muscle mass are not always available due to their high cost and/or time-consuming, or because they are not easy-to-use by any health-care professional nor practical within the daily hospital routine [6]. However, physical performance tests might be available even at the most resource-limited settings and are easy-to-use tools by any health-care professional [6]. Handgrip strength has been proposed as an alternative tool to estimate muscle mass as probably is one of the most affordable and easy-to-use tools in clinical settings due to its simple assessment and easy adaptation to almost every inpatient (bedridden or not) [6,9,10]. Thus, the identification of such surrogate measurements of muscle mass seems crucial for malnutrition management [6]. Likewise, the Short Physical Performance Battery (SPPB) has also gained attention and might be valuable, as it is widely used in clinical settings for physical performance assessment within older adult population [11].
Handgrip strength has been proposed as a biomarker for health status in older adults due to its clinical and prognostic value [12] and poor performance within the SPPB has been linked to all-cause mortality [13]. Reference values for the SPPB [14] and handgrip strength [15, 16] have been published describing older adults’ population as well as general normative data by age groups for the SPPB [17] and handgrip strength [18]. Likewise, it is of clinical and public health interest to feature the physical status of the older inpatients in comparison to their healthy counterparts [10, 12]. This would add further clinical information to track the overall health status of patients and to design intervention programs in order to maintain and/or improve muscle mass and strength [15].

The usefulness of handgrip strength for nutrition assessment merits further research as there is conflicting data due to small sample sizes regarding older adults [19]. Similarly, the SPPB has shown a strong association with malnutrition in older inpatients [20], but the associations of each of the subtests with malnutrition have not been studied yet in hospitalized older adults. This might be of interest as two of those subtests (gait speed and 5 times sit-to-stand tests) reflect muscle power, which has been suggested to be a better discriminatory predictor of functional performance than muscle strength [21].

Thereby, this study aimed to (i) characterize the physical condition of hospitalized older patients according to recently published reference percentile values for handgrip strength and for the SPPB total score and two of its subtests, and (ii) to examine the association between malnutrition and the physical performance of the studied sample.
Materials and Methods

Study design

This study was a cross-sectional secondary analysis conducted as part of the recruitment for a randomized controlled trial (ClinicalTrials.gov ID: NCT03815201) at the internal medicine service of the Araba University Hospital in Vitoria-Gasteiz (Spain) from September 2017 to July 2018. The study was approved by the Clinical Research Ethics Committee of the Araba University Hospital (CEIC-HUA: 2017-021) and complied with the revised ethical guidelines of the Declaration of Helsinki (revision of 2013). All patients were informed about the details of the research and signed an informed consent for their evaluation during hospitalization.

Participants

Members of the research team, with a wide experience in clinical settings, revisited the daily list of patients admitted to the internal service in order to assess eligibility. The reasons for hospitalization can be found in a study published by our research group [22] and coincide with those that can be expected for a geriatric population. The average length of hospital stay for older adults admitted to this hospital ward was 7.9 ± 5.2 days. Patients meeting the following criteria were eligible for inclusion and were evaluated within the first 3 days upon admission: ≥ 70 years old, ≥ 20 cut-off at the Mini Mental State Questionnaire, were able to walk alone or using assistive devices (cane, crutch,…), were able to understand and follow the instructions, and signed the informed consent. However, they were not eligible for evaluation if they had any of the following exclusion criteria: been suffering from severe dementia or Parkinson, been unable to stand and/or walk a short distance, been in critical medical condition or death, and if they had suffered any fracture of the upper or lower limbs in the last 3 months. For the current study, we included participants with valid data on
nutritional status assessed by the Mini Nutritional Assessment-Short Form (MNA-SF)

From the 1878 hospitalized patients, a total of 775 (41.3%) patients met the
inclusion criteria (Figure 1). However, 32 (4.1%) refused to be evaluated, 21 (2.7%)
were moved to another medical service or hospital, and 113 (14.6%) had been
discharged with not chance to be interviewed. Finally, 604 participants were included in
the current study (n=5 did not have MNA-SF score data) (Figure 1).

Data collection

The medical history and number of drugs given to the patients at the time
admitted to hospital were obtained by revising the clinical records. For the current
study, polypharmacy was defined as the routine use of ≥ 5 drugs [23] and the
comorbidity burden was defined by the Charlson Comorbidity Index [24].

Nutritional Assessment

Nutritional status was assessed by the MNA-SF (Nestlé Nutrition Institute, [25])
questionnaire directly with the patients and/or their respective relatives or caregivers.
The MNA-SF has been proposed as a valid screening test to identify old
institutionalized participants with malnutrition [25]. This questionnaire comprises 6-
items and each answer has a numerical value contributing to the final score [25]. A
maximum of 14 points can be obtained and depending on the score, the following
categories are described: 0-7 points malnutrition, 8-11 points at risk of malnutrition and
12-14 points normal nutritional status [25]. The last item of the MNA-SF can be
answered by body mass index estimation or by measuring the calf circumference [25].
As we had difficulties to measure height in several patients, we decided to use calf
circumference following the standard protocol recommended by the International
Society for the Advancement of Kinanthropometry. When possible, body mass (kg) was
measured barefoot based on standardized protocols (OMROM HN-288, Digital
Personal Scale, Barcelona, Spain).

For several analyses, the three MNA-SF categories were re-coded into two
categories. Those at risk of malnutrition or with malnutrition were grouped together into
“malnutrition or risk of malnutrition” as both are considered risk factors within older
adult population, and the remaining category was “normal nutritional status”.

*Physical Performance Assessment*

Physical performance was assessed by two tests: handgrip strength and the SPPB.
Hence, the gait speed and the 5 times sit-to-stand tests, which are part of the SPPB,
were also analysed separately to assess physical performance.

Dominant handgrip strength (kg) was measured by a handheld dynamometer
(JAMAR® PLUS + Hand dynamometer) in a seating position, as it has been proposed
for older adults in clinical practice [26]. Patients were classified as fit (>P25) or unfit
(≤P25) according to reference percentile values for handgrip strength published by
Dodds et al.[18].

Physical performance of the lower limbs was evaluated using the SPPB clinical
tool [27]. The SPPB assessment methodology has been published elsewhere [27] and
includes 3 subtests: 1) the standing balance test, 2) the gait speed test and 3) the 5 times
sit-to-stand test. The total SPPB score ranges from 0 to 12, with the score of each
subtest ranging from 0 to 4 points. According to the total score obtained, 4 clinically
relevant categories have been defined for the SPPB: from 0 to 3, from 4 to 6, from 7 to
9 and from 10 to12 points [27]. It has been shown that scores below 10 points are
associated with mobility-related disability [28] and/or with increased risk of death [13].
Hence, the SPPB has been proposed as a good discriminatory tool for frailty and the
threshold for its assessment have been established at scores ≤9 [29, 30]. So, it was
decided to classify those inpatients with scores ranging from 0 to 9 as “frail” and those
with scores ranging from 10 to 12 as “non-frail” [13, 29, 30].

Patients were also classified independently as fit (>P25) or unfit (≤P25) for the
SPPB total score, the gait speed test and the 5 times sit-to-stand test according to the
reference percentile values published by Bergland et al.[17].

Statistical analysis

The distribution of the variables was verified using the Shapiro–Wilks test,
skewness and kurtosis values and those variables with non-normal distribution were
logarithmically transformed (i.e., age, body mass (kg), Charlson Comorbidity Index,
SPPB total score as well as gait speed (m/s), 5 times sit-to-stand tests (sec), and MNA-
SF score). Differences in sociodemographic and clinical characteristics between women
and men were analysed using the independent Student \( t \) test and the Chi-square test for
continuous and categorical variables, respectively. Univariable analysis was conducted
to describe the distribution of the sample (absolute and relative frequencies) across the
reference percentile values for handgrip strength, the SPPB total score, the gait speed
test and the 5 times sit-to-stand test.

Pearson’s correlation was used to analyse the association between continuous
variables (the MNA-SF score with each physical performance test). Analysis of
variance (polynomial) was done to compare the mean values for each physical
performance test among the 3 nutritional status categories (normal nutritional status,
risk of malnutrition and malnutrition) with Bonferroni adjustment. Binary logistic
regression models were carried out to analyse the risk for being classified as unfit
(within the different physical performance tests: handgrip strength, SPPB total score,
gait speed test and 5 times sit-to-stand test) or frail for the SPPB total score according to
the nutritional status (“malnutrition or risk of malnutrition” vs. “normal nutritional status”).

All statistical analyses were done using the statistical software SPSS version 20.0 (SPSS Inc., Chicago, IL, USA) with a level of significance of $\alpha = 0.05$. Data are expressed as means ± SEM, unless other is indicated.
Results

Clinical characteristics of participants

Table 1 shows clinical characteristics of participants by gender. Women were older and had lower body mass than men (all \( p < 0.01 \), Table 1). It was also observed that women had significantly higher rates of depression, but lower rates of cardiovascular disease, chronic obstructive pulmonary disease, diabetes, kidney disease and neoplasia than men (all \( p < 0.05 \), Table 1). Hence, women had significantly lower Charlson Comorbidity Index score than men (\( p < 0.001 \), Table 1).

Men scored significantly higher in the MNA-SF test than women (\( p < 0.005 \), Table 1) and performed significantly better than women within all physical tests (all \( p < 0.05 \), Table 1).

Physical performance in hospitalized patients

Table 2 shows the distribution of the hospitalized patients according to reference percentile values [17, 18]. For handgrip strength test, almost 50% of women and more than one half (58.3%) of men patients were \( \leq P25 \). However, more than 80% of patients were \( \leq P25 \) for SPPB total score (88.7% women and 83.9% men), gait speed test (92.4% women and 81.2% men) and 5 times sit-to-stand test (91.1% women and 91.1% men).

Association of nutritional status and physical performance

The associations of nutritional status, assessed by the MNA-SF test, with the physical performance tests are shown in Table 3. Better nutritional status was significantly associated with better performance in handgrip strength, gait speed and the 5 times sit-to-stand tests, as well as with higher SPPB total score (all \( p < 0.001 \), Table 3).

Likelihood of being classified as unfit or frail by malnutrition status
The likelihood for being classified as unfit or frail within different physical assessment tests according to the nutritional status are shown in Figure 2. It was observed that patients classified as being at risk of malnutrition or having malnutrition had higher likelihood of being classified as unfit for handgrip strength test \((p = 0.027)\), SPPB total score \((p < 0.001)\), and gait speed test \((p < 0.001)\), as well as being frail according to the SPPB frailty threshold \((p < 0.001)\) (Figure 2). Hence, patients at risk of malnutrition or having malnutrition had > 4.5 times higher risk for being classified as frail according to the SPPB frailty threshold, and 4.0 times for being classified as unfit for the gait speed test, > 2.5 times for the SPPB total score and 1.5 times for the handgrip strength test (Figure 2). However, being at risk of malnutrition or having malnutrition did not increase the likelihood of being classified as unfit for the 5 times sit-to-stand test \((p = 0.458, \text{ Figure 2})\). Hence, when those older inpatients that were not able to perform the 5 times sit-to-stand test were included within the unfit group the results did not substantially change (OR: 1.889, 95% CI: 0.952-3.749, \(p = 0.069\)).

Differences within each physical performance test according to the nutritional status categories are shown in Figure 3. It was observed that as the nutritional status worsen the performance within all the physical tests declined too (all \(p\) for trend < 0.001, Figure 3).
Discussion

The main findings of the current study were that hospitalized older patients (≥ 70 years old) showed an impaired physical performance compared to their healthy counterparts, and that this decline within different physical tests was associated with worse nutritional status. Hence, being at risk of malnutrition or malnourished increased the risk for being classified as unfit for the handgrip test, the SPPB score and the gait speed test, and as frail according to the SPPB frailty threshold. Thus, the early identification of those patients malnourished or at risk of malnutrition seems important as it might also help to identify those patients at risk of impaired physical performance and/or frailty in clinical settings.

Normative reference values help to track the physical performance of an individual over time in contrast to their healthy counterparts [15] and might add clinical value to the physical screening of hospitalized older adults. In the current study, more than a half of the older inpatients were ≤P25 for handgrip strength [18], and almost all measured patients were below ≤P25 for the SPPB score, the gait speed test, and the 5 times sit-to-stand test [17], being more than 50% of them below P5. Thus, the older inpatients in this study exhibited a poor physical performance which fell far below what it would have been considered appropriate for their age. However, when our results are compared to those from hospitalized older adults with a mean age of ≥80 years old [21, 31, 32], patients in our study showed better performance within handgrip strength, SPPB total score and 5 times sit-to-stand test. These results suggest that the hospitalized older adults in our study were in better physical condition, although sample sizes in those studies were smaller. Nevertheless, when our results are compared to other studies with larger sample sizes and a mean age around 68 years old, the older inpatients in our study showed worse physical performance, especially male patients [33, 34]. Indeed,
confirming that muscle strength and function decrease with aging and the decrease seems steeper within men [15, 35].

Our study also showed that the 65.7% of the hospitalized older adults were at risk of malnutrition or malnourished assessed by the MNA-SF questionnaire during their hospitalization. This prevalence is within the range showed by other studies carried in clinical settings [21, 36–40], confirming that a high proportion of older inpatients are already malnourished or that are at high risk of malnutrition [41].

It is well-known that a consequence of malnutrition is muscle mass loss, with the subsequent negative effects on muscle function and, therefore, on physical performance [6]. This could be reflected by the results from this study, showing associations between the nutritional status and handgrip strength and SPPB score as well as its subtests. Hence, according to those physical performance tests, significant differences were seen between patients at risk of malnutrition or malnourished and with a normal nutritional status. To our knowledge, this is the first study examining the association of both handgrip strength and SPPB, as well as two of its subtests separately, with nutritional status in a large sample of hospitalized older adults. Recently, Ramsey et al. [42] published a similar study, but in geriatric outpatients, confirming a positive association between nutritional status and SPPB score, gait speed, and 5 times sit-to-stand tests. However, contrary to our results, but in accordance with other studies of hospitalized older adults [20, 42, 43], Ramsey et al. [42] did not observe any association between handgrip strength and nutritional status. Although, handgrip strength has been proposed as a potentially useful and rapid tool for nutritional assessment in hospital patients [10, 19, 34, 44], this needs further research in older adult inpatients due to conflicting data. Those studies reporting an association between handgrip strength and nutritional status, included patients older than 18 years old encompassing a wide age range [10, 19, 34,
44], whereas in studies where no association have been seen age was limited to ≥65 years old [20, 42, 43]. These study characteristics and the smaller sample sizes accompanied by the different nutritional screening tool employed in those studies [20, 42, 43], might have hidden any association limiting comparisons with our study.

The usage of the SPPB and its subtests for nutritional assessment has not been yet studied [13], albeit an association between this battery and the nutritional status of older adults has been confirmed in several studies [9, 21, 45, 46]. In agreement with our findings, Ramsey et al. [42] reported significant associations of the SPPB and its subtests with malnutrition assessed by the Short Nutritional Assessment Questionnaire in geriatric outpatients. Therefore, the SPPB as well as each of its subtests might have individual value in relation to malnutrition. Hence, Mendes et al. [49] suggested that gait speed might have a potential capacity to identify poor nutritional outcomes, as it showed high sensitivity values similar to those of nutritional assessment tools. In this line, we also observed that being at risk of malnutrition or malnourished increased more than twice or four times the risk for been classified as unfit according to the SPPB total score and the gait speed test, respectively, in comparison to handgrip strength, which increased the risk 1.5 times. These results suggest that upper and lower limbs’ strength might be affected differently by nutritional status [42], as it occurs with the ageing process [50]. However, the same significant results were not shown for the 5 times sit-to-stand test. This test is suggested to capture advanced stages of disability, but it has some limitations as older adults that are not able to perform the test have no time recorded for it [11,27]. The proposed normative values for the 5 times sit-to-stand test by Bergland et al. [17] were based on the time needed to perform the test. So, those older inpatients unable to perform the test were not included within the fit/unfit classification. Thus, this inability to perform the test by a high percentage of the older
adults in the current study along with the low number of patients classified as fit (only 35 patients) might have limited the results.

Finally, a relevant finding of our study was that those patients at risk of malnutrition or malnourished had >4.5 higher risk of being classified as frail according to the SPPB frailty threshold. This association between malnutrition and frailty has been reported by other studies, but frailty assessment was based on different criteria other than SPPB categories, such as the Frailty Instrument for Primary Care of the Survey of Health, Ageing and Retirement in Europe [51] and the Fried frailty criteria [52]. Indeed, those frailty criteria contained items that were shared by the MNA-SF questionnaire, so it is not surprising to have found an association [49, 50]. However, this was not the case in our study as frailty assessment was based only on physical performance measurement (SPPB frailty threshold), without subjective questions shared by the MNA-SF. Thus, our study reinforces the link between malnutrition and physical performance level [52].

Physical performance assessment by the SPPB might have some limitations in clinical settings. Indeed, the assessment by this battery requires some space and time to perform the different subtests as well as the adequacy to a standardized protocol [27]. Thus, the results from this study reinforce the use of the MNA-SF for those clinical settings where is not feasible to assess physical performance by the SPPB. Nevertheless, once the SPPB is included into the daily routine of clinical settings, its assessment might not take more time than other tests [29] and given its ability to predict adverse health outcomes its assessment could be preferred in certain clinical settings [13].

In conclusion, our study brings new insights into malnutrition management, reinforcing the use of handgrip and SPPB, as well as its subtests, in hospitalized older adults to complement nutritional screening [6]. In addition, it seems that when physical
performance assessment is not feasible, nutritional status assessed by the MNA-SF might help to predict poor physical performance in hospitalized older adults.

**Strengths and limitations**

One of the strengths of the study is that to the best of our knowledge this is the first study including a large sample (n=604) of hospitalized older adults (≥70 years old) to examine their nutritional status and its association with the most widely and easy-to-use physical performance tests in clinical settings (handgrip strength and SPPB). However, the reference percentile values we used in our study were from European countries other than Spain. Thus, it would be interesting for future studies to publish standardized reference values for the Spanish population. Another limitation of our study is its cross-sectional design that limits to determine any causality. In addition, our results cannot be extrapolated to older inpatients not meeting our inclusion criteria and to other clinical settings, such as nursing homes and/or to community-dwelling older adults. Future studies in different context should examine the usefulness of the different physical performance tests to complement the nutritional assessment.

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**Statement of Authorship**

IL, AB, and JI designed the study, MA and MU collected the data, MA, MM and IL interpreted the data and drafted the manuscript, MA, AB, MM, MU, ARL, IT, JB, JI,
and IL have approved the submitted version and agree to be personally accountable for the author’s own contributions and for ensuring that questions related to the accuracy or integrity of any part of the work, even ones in which the author was not personally involved, are appropriately investigated, resolved, and documented in the literature.

**Conflict of Interest Statement**

Maria Amasene, Ariadna Besga, María Medrano, Miriam Urquiza, Ana Rodriguez-Larrad, Ignacio Tobalina, Julia Barroso, Jon Irazusta and Idoia Labayen declare no conflict of interest. The founding sponsors had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, and in the decision to publish the results.

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Age Trajectories of Grip Strength: Cross-Sectional and Longitudinal Data


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https://doi.org/10.1016/j.jamda.2020.03.006.


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FIGURE LEGENDS

**Fig. 1** Flow diagram of participants

**Fig. 2** Odd Ratios and 95% confidence intervals for being classified as unfit or frail according to different fitness tests (handgrip, SPPB, gait speed test and 5 times sit-to-stand test) in those patients at risk of malnutrition or with malnutrition (MNA-SF total score ≤ 11). Abbreviations: MNA-SF: Mini Nutritional Assessment-Short Form; Unfit-SPPB: Unfit-Short Physical Performance Battery; Frailty-SPPB: frailty-Short Physical Performance Battery. Unadjusted odds ratios. Handgrip unfit assessment according to Dodds et al. [18] percentiles; Short Physical Performance Battery unfit assessment according to Bergland et al. [17] percentiles; gait speed test unfit assessment according to Bergland et al. [17] percentiles; 5 times sit-to-stand test unfit assessment according to Bergland et al. [17] percentiles; Frailty assessment according to the Short Physical Performance Battery frailty threshold

**Fig. 3** Differences among physical function parameters according to the nutritional status categories. (a) handgrip (kg) (b) Short Physical Performance Battery (SPPB) total score (c) gait speed test (m/s) (d) 5 times sit-to-stand test (sec). Abbreviations: SPPB total score: Short Physical Performance Battery score. a: $p < 0.001$ denotes significant differences between patients with normal nutritional status and patients at risk of malnutrition or with malnutrition. b: $p < 0.001$ denotes significant difference between patients at risk of malnutrition and with malnutrition. c: $p < 0.05$ denotes significant difference between patients with malnutrition and patients at risk of malnutrition. d: $p < 0.005$ denotes significant difference between patients with normal nutritional status and patients at risk of malnutrition. Unadjusted analysis of variance (polynomial)
## Table 1 Characteristics of participants in the study by gender

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>N</th>
<th>Total</th>
<th>Women</th>
<th>Men</th>
<th>P*</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age (years)</strong></td>
<td>604</td>
<td>84.3 (6.8)</td>
<td>304 85.1 (6.9)</td>
<td>300 83.4 (6.5)</td>
<td>&lt; 0.005†</td>
</tr>
<tr>
<td><strong>Body mass (kg)</strong></td>
<td>589</td>
<td>67.2 (13.3)</td>
<td>296 62.8 (12.8)</td>
<td>293 71.6 (12.2)</td>
<td>&lt; 0.001†</td>
</tr>
<tr>
<td><strong>Number of drugs</strong></td>
<td>604</td>
<td>7.2 (3.7)</td>
<td>304 7.1 (3.6)</td>
<td>300 7.4 (3.9)</td>
<td>0.742†</td>
</tr>
<tr>
<td><strong>Polypharmacy (N, %)</strong></td>
<td>604</td>
<td>455, 75.3</td>
<td>304 226, 74.3</td>
<td>300 229, 76.3</td>
<td>0.571</td>
</tr>
<tr>
<td><strong>Depression (N, %)</strong></td>
<td>604</td>
<td>56, 9.3</td>
<td>304 40, 13.2</td>
<td>300 16, 5.3</td>
<td>&lt; 0.005</td>
</tr>
<tr>
<td><strong>Diseases</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hypertension (N, %)</td>
<td>604</td>
<td>446, 73.8</td>
<td>304 224, 73.7</td>
<td>300 222, 74.0</td>
<td>0.930</td>
</tr>
<tr>
<td>CVD (N, %)</td>
<td>604</td>
<td>179, 29.6</td>
<td>304 71, 23.4</td>
<td>300 108, 36.0</td>
<td>&lt; 0.005</td>
</tr>
<tr>
<td>COPD (N, %)</td>
<td>604</td>
<td>121, 20.0</td>
<td>304 38, 12.5</td>
<td>300 83, 27.7</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Diabetes (N, %)</td>
<td>604</td>
<td>206, 34.1</td>
<td>304 88, 28.9</td>
<td>300 118, 39.3</td>
<td>&lt; 0.05</td>
</tr>
<tr>
<td>Kidney disease (N, %)</td>
<td>604</td>
<td>109, 18.0</td>
<td>304 42, 13.8</td>
<td>300 67, 22.3</td>
<td>&lt; 0.05</td>
</tr>
<tr>
<td>Hepatic disease (N, %)</td>
<td>604</td>
<td>13, 2.2</td>
<td>304 6, 2.0</td>
<td>300 7, 2.3</td>
<td>0.761</td>
</tr>
<tr>
<td>Neoplasia (N, %)</td>
<td>604</td>
<td>124, 20.5</td>
<td>304 40, 13.2</td>
<td>300 84, 28.0</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Dementia (N, %)</td>
<td>604</td>
<td>23, 3.8</td>
<td>304 16, 5.3</td>
<td>300 7, 2.3</td>
<td>0.060</td>
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<tr>
<td>Parkinson (N, %)</td>
<td>604</td>
<td>19, 3.1</td>
<td>304 10, 3.3</td>
<td>300 9, 3.0</td>
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<tr>
<td><strong>Charlson Comorbidity Index</strong></td>
<td>597</td>
<td>6.3 (2.1)</td>
<td>300 5.8 (1.7)</td>
<td>297 6.7 (2.2)</td>
<td>&lt; 0.001†</td>
</tr>
<tr>
<td><strong>Physical Function</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Handgrip (kg)</td>
<td>603</td>
<td>19.6 (8.3)</td>
<td>303 14.6 (5.5)</td>
<td>300 24.5 (7.6)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>SPPB total score</td>
<td>598</td>
<td>5.4 (3.1)</td>
<td>300 4.7 (2.9)</td>
<td>298 6.1 (3.2)</td>
<td>&lt; 0.001†</td>
</tr>
<tr>
<td>0-3 (N, %)</td>
<td>598</td>
<td>190, 31.8</td>
<td>300 119, 39.7</td>
<td>298 71, 23.8</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>4-6 (N, %)</td>
<td>598</td>
<td>193, 32.3</td>
<td>300 99, 33.0</td>
<td>298 94, 31.5</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>7-9 (N, %)</td>
<td>598</td>
<td>138, 23.1</td>
<td>300 58, 19.3</td>
<td>298 80, 26.8</td>
<td></td>
</tr>
<tr>
<td>10-12 (N, %)</td>
<td>598</td>
<td>77, 12.9</td>
<td>300 24, 8.0</td>
<td>298 53, 17.8</td>
<td></td>
</tr>
<tr>
<td>Gait speed test (m/s)</td>
<td>598</td>
<td>0.5 (0.3)</td>
<td>300 0.4 (0.2)</td>
<td>298 0.6 (0.3)</td>
<td>&lt; 0.001†</td>
</tr>
<tr>
<td>5 times sit-to-stand test (sec)</td>
<td>394</td>
<td>19.6 (8.7)</td>
<td>180 20.9 (9.8)</td>
<td>214 18.4 (7.5)</td>
<td>&lt; 0.05†</td>
</tr>
<tr>
<td><strong>Nutritional Status</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Mini Nutritional Assessment-Short Form score</td>
<td>604</td>
<td>10.0 (2.5)</td>
<td>304 9.6 (2.6)</td>
<td>300 10.4 (2.3)</td>
<td>&lt; 0.005†</td>
</tr>
<tr>
<td>Normal nutritional status (N, %)</td>
<td>604</td>
<td>207, 34.3</td>
<td>304 87, 28.6</td>
<td>300 120, 40.0</td>
<td>0.001</td>
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<tr>
<td>At risk of malnutrition (N, %)</td>
<td>604</td>
<td>293, 48.5</td>
<td>304 151, 49.7</td>
<td>300 142, 47.3</td>
<td></td>
</tr>
<tr>
<td>Malnourished (N, %)</td>
<td>604</td>
<td>104, 17.2</td>
<td>304 66, 21.7</td>
<td>300 38, 12.7</td>
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</tr>
</tbody>
</table>
Abbreviations: CVD: cardiovascular disease; COPD: chronic obstructive pulmonary disease; SPPB total score: Short Physical Performance Battery total score. Values are means and standard deviations unless otherwise is indicated. *p refers to differences between men and women analyzed by t test for independent samples in continuous variables and Chi-squared test for categorical variables. †means and standard deviations are presented for not transformed variables to ease interpretation, but p were obtained by t test for independent samples with logarithmically transformed continuous variables.

aData were missing for 15 patients
bData were missing for 7 patients
cData was missing for 1 patient
dData were missing for 6 patients
eData were missing for 210 patients
<table>
<thead>
<tr>
<th></th>
<th>≤P5</th>
<th>&gt;P5 - ≤P10</th>
<th>&gt;P10 - ≤P25</th>
<th>&gt;P25 - ≤P50</th>
<th>&gt;P50 - ≤P75</th>
<th>&gt;P75 - ≤P90</th>
<th>&gt;P90</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Handgrip (kg) (N, %)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Women</td>
<td>-</td>
<td>177, 29.4</td>
<td>136, 22.6</td>
<td>183, 30.3</td>
<td>65, 10.8</td>
<td>29, 4.8</td>
<td>13, 2.2</td>
</tr>
<tr>
<td>Men</td>
<td>-</td>
<td>80, 26.4</td>
<td>58, 19.1</td>
<td>99, 32.7</td>
<td>37, 12.2</td>
<td>21, 6.9</td>
<td>8,  2.6</td>
</tr>
<tr>
<td><strong>SPPB total score (N, %)</strong></td>
<td>341, 57.0</td>
<td>86, 14.4</td>
<td>89, 14.9</td>
<td>57, 9.5</td>
<td>7, 1.2</td>
<td>-</td>
<td>18, 3.0</td>
</tr>
<tr>
<td>Women</td>
<td>170, 56.7</td>
<td>50, 16.7</td>
<td>46, 15.3</td>
<td>22, 7.3</td>
<td>7, 2.3</td>
<td>-</td>
<td>5,  1.7</td>
</tr>
<tr>
<td>Men</td>
<td>171, 57.4</td>
<td>36, 12.1</td>
<td>43, 14.4</td>
<td>35, 11.7</td>
<td>-</td>
<td>-</td>
<td>13, 4.4</td>
</tr>
<tr>
<td><strong>Gait speed test (m/s) (N, %)</strong></td>
<td>414, 69.2</td>
<td>42, 7.0</td>
<td>63, 10.5</td>
<td>48, 8.0</td>
<td>22, 3.7</td>
<td>6, 1.0</td>
<td>3,  0.5</td>
</tr>
<tr>
<td>Women</td>
<td>230, 76.7</td>
<td>20, 6.7</td>
<td>27, 9.0</td>
<td>15, 5.0</td>
<td>5, 1.7</td>
<td>3, 1.0</td>
<td>-</td>
</tr>
<tr>
<td>Men</td>
<td>184, 61.7</td>
<td>22, 7.4</td>
<td>36, 12.1</td>
<td>33, 11.1</td>
<td>17, 5.7</td>
<td>3, 1.0</td>
<td>3,  1.0</td>
</tr>
<tr>
<td><strong>5 times sit-to-stand test (sec) (N, %)</strong></td>
<td>235, 59.6</td>
<td>69, 17.5</td>
<td>55, 14.0</td>
<td>26, 6.6</td>
<td>7, 1.8</td>
<td>2, 0.5</td>
<td>-</td>
</tr>
<tr>
<td>Women</td>
<td>112, 62.2</td>
<td>33, 18.3</td>
<td>19, 10.6</td>
<td>12, 6.7</td>
<td>3, 1.7</td>
<td>1, 0.6</td>
<td>-</td>
</tr>
<tr>
<td>Men</td>
<td>123, 57.5</td>
<td>36, 16.8</td>
<td>36, 16.8</td>
<td>14, 6.5</td>
<td>4, 1.9</td>
<td>1, 0.5</td>
<td>-</td>
</tr>
</tbody>
</table>

Abbreviations: SPPB: Short Physical Performance Battery. Data are presented as number and %. Handgrip percentiles according to Dodds et al [18]; SPPB total score, gait speed test (m/s) and 5 times sit-to-stand test (sec) percentiles according to Bergland et al. [17].
Table 3 Association of nutritional status assessed by the Mini Nutritional Assessment-Short Form (MNA-SF) test with physical function tests

<table>
<thead>
<tr>
<th></th>
<th>Handgrip (kg)</th>
<th>SPPB (total score)</th>
<th>Gait speed test (m/sec)</th>
<th>5 times sit-to-stand test (sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MNA-SF (lineal)</td>
<td>0.286</td>
<td>0.315</td>
<td>0.266</td>
<td>-0.189</td>
</tr>
<tr>
<td></td>
<td>&lt; 0.001</td>
<td>&lt; 0.001</td>
<td>&lt; 0.001</td>
<td>&lt; 0.001</td>
</tr>
</tbody>
</table>

Abbreviations: MNA-SF: Mini Nutritional Assessment-Short Form; SPPB (total score): Short Physical Performance Battery (total score). Unadjusted correlation tests. Pearson’s correlations were calculated with the logarithmically transformed variables, except for handgrip strength.
<table>
<thead>
<tr>
<th>Fitness test</th>
<th>OR (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Handgrip</td>
<td>1.485 (1.045-2.056)</td>
</tr>
<tr>
<td>SPPB Score</td>
<td>2.553 (1.592-4.094)</td>
</tr>
<tr>
<td>Gait speed test</td>
<td>4.049 (2.469-6.640)</td>
</tr>
<tr>
<td>6 times sit-to-stand test</td>
<td>1.301 (0.649-2.007)</td>
</tr>
<tr>
<td>SPPB-Frailty degree</td>
<td>4.675 (2.812-7.772)</td>
</tr>
</tbody>
</table>